


LILAVATI'S DAUGHTERS

The Women Scientists of India


 अब बायाँ १२ रवेर हा। अब बायाँ १८ रवेर हा। बायाँ २४ रवेर १२। सुनने बायाँ रवेर हा। यदि मित्र लेखने रवेर कांति म्हा बायाँ रवेर मित्र लेखने किं बा
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edited by

ROHINI GODBOLE

RAM RAMASWAMY

LILAVATI'S DAUGHTERS

अये बाले लीलावति मतिमति ब्रूहि सहितान्
द्विपञ्चद्वित्रिंशत् त्रिनवति शताष्टादश दश ।
शतोपेतानेतानयुतवियुतांश्चापि वद मे
यदि व्यक्ते युक्तिं व्यवकलनमार्गेऽसि कुशला ॥

LILAVATI'S DAUGHTERS

The Women Scientists of India

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ISBN 978-81-8465-005-1

Price: Rs. 300/-

Printed by Brilliant Printers Pvt. Ltd., Bangalore 560 094, India
email:info@brilliantprinters.com

Original Print: December 2008
Reprint: July 2010, January 2014, October 2016

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Preface

O! Lilavati, intelligent girl, if you understand addition and subtraction, tell me the sum of the amounts...

In the eight years since *Lilavati's Daughters* (LD) was first published, this is the third time we have had to print additional copies. There have been some developments particularly to do with translations into a number of Indian languages, and the present reprinting gives us the opportunity of updating the original Preface.

Even with the fourth printing, the total number of copies of LD in circulation is not very large – it comes to 11,000 now – but it would be accurate to say that we are both surprised and very pleased by the reception that the book has got. As we have remarked earlier, the idea of the book came up at a time when the issue of the underrepresentation of women in the sciences in India was beginning to be discussed. The Women in Science (WiS) panel of the Indian Academy of Sciences, Bangalore thought that it might be both interesting and inspirational for young children to learn more about Indian women scientists.

The first idea was to put together a collection of biographical sketches of influential Indian women scientists of earlier generations, to underline the fact that it is possible to find role models within the country. (A working model of just such a collection had appeared around that time: *One Hundred Reasons to be a Scientist*, by K. R. Sreenivasan, Director of the International Center for Theoretical Physics, Trieste. About a hundred highly reputed scientists from all over the world shared what attracted them to science as youngsters and kept their interest alive.) We further felt that it was important, especially for young girls with

research ambitions, to know of women who functioned and achieved their goals in the Indian social and academic environment.

Lilavati's Daughters shared some of the features of *One Hundred Reasons*, but was also quite different. We wanted this collection of essays to mirror our cultural diversity, and to cover a range of disciplines so that any woman student could gain from the insights and experiences of other women to whom they might have been able to relate at many levels. We had therefore asked our contributors to give some idea of the journey on the path of science – the passions that help keep the motivation strong, the tribulations they might have undergone. We had also asked them to talk about what helped in their careers, as well as what did not.

The women scientists who eventually featured in *Lilavati's Daughters* gave generously of themselves, sharing their stories with candour and with warmth. The set of nearly one hundred essays (some biographical as well) gives some flavour of what it takes to be a woman scientist in India today. Negotiating through the diversity of cultures, regional distinctions, languages and traditions in order to pursue a career in science has its complexities. It was interesting to learn from these narratives that achieving a balance between family and career was just one of the many challenges in the journey of many!

There are now editions of LD in Malayalam (*Leelavathiyude Penmakal*, 2013, Kerala Sasthra Sahithya Parishath, Thrissur), and partial translations into Marathi (Loksatta, 2009, Vidynayanmayee Series, Chaturang Supplement), Hindi (Shaikshanik Sandarbh, 2009, 2010 (volumes 63 – 67), Eklavya, Bhopal), Kannada (Ganitashastradalli Minchida Mahileyaru, 2012, Karnataka Rajya Vijnana Parishat, chapters 20 – 28) and Gujarati (Sandarbh, 2011, Nachiketa and ARCH (Action Research in Community Health)). Further, a shorter version of LD meant for a younger audience has appeared as “*A Girl's Guide to a Life in Science*” (GGLS). The essays therein have been extended to include a description of the scientific field as well; GGLS is a

Appreciation for LD has appeared in both the local as well as the international press [1], and the attractiveness of the first-person narratives lent itself easily to translation across cultures [2]. There is a presence on social media as well, with an LD page on FaceBook, and entries in Wikipedia in English as well as a number of Indian languages [3,4]. We are therefore particularly grateful to our contributors for helping to make this a very personal book that conveys courage, dedication, and aspiration. In the end, however, the value of LD will be gauged by the difference that comes about in the scientific workplace, when gender considerations will cease to play a determining or limiting role. It is too early to tell, but the signs are encouraging.

Rohini Godbole

Bengaluru

Ram Ramaswamy

New Delhi

October 2016

- [1] *Indian Women In Science*, V. Venkataraman, C&E News, 87, 68 (2009); *Forgotten Daughters*, V. Venkataraman, The Hindu, April 5, 2009; *Bridging the gender gap in Indian science*, A. Gopinathan, Nature **460**, 1082 (2009); *A playful side to twelfth-century mathematics*, R. Ramaswamy and R. Godbole, Nature **461**, 1198 (2009).
- [2] Coincidentally, around the same time that LD was first published, the Royal Society (London) brought out *Mothers in Science*, a collection of 64 brief biographies of women scientists, with a focus on the career-family balance. This book can be downloaded from the site <http://goo.gl/EkaFqh> . Currently the Royal Society is on a drive to increase the number of stories to 250.
- [3] The Wikipedia page is at <http://goo.gl/Vd49mK>
- [4] The Lilavati's Daughters Edit-a-thon on Wikimedia is at <http://goo.gl/AaxRQQ>

We are sad to report that in the time since the project started in 2006, the following contributors to the book have passed on.

Sipra Guha-Mukherjee, on 15 September 2007

Anjali Mookerjee, on 30 May 2009

Satyavati M Sirsat, on 10 July 2010

Rajeshwari Chatterjee, on 3 September 2010

Priti Shankar, on 17 October 2011

V Kalpagam, on 6 January 2015

Maharani Chakravorty, on 16 January 2015

Purnima Sinha, on 11 July 2015,

Kusum Marathe, on 6 August 2015

Charusita Chakravarty, on 29 March 2016.

We were privileged to have known them, and fortunate that they shared their stories with us.

Rohini Godbole

Ram Ramaswamy

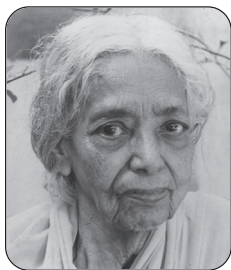
Acknowledgements

A large number of people have helped us in this endeavour and we would like to take this opportunity to express our sincere thanks to them. Tina Franco, P. K. Jayanthan, Sharvari Navale, Saashi Subodh and Ruth Vanita edited many of the essays at different stages. We would like to express our thanks to Mr G. Madhavan of the Indian Academy of Sciences for his help in making this project a reality. The staff of the Indian Academy of Sciences, Mrs R. Pushpavathi, Ms M. K. Anitha and Mrs M. Srimathi in particular, have worked tirelessly to see to its completion. A big thank you also to our artists Mr Trinankur Banerjee and Mrs Jayati Naravane. We also wish to express our gratitude to the Bhandarkar Oriental Research Institute (BORI) in Pune who provided us access to some of the old manuscripts related to Bhaskara's Lilavati, excerpts from which adorn the cover.

We would particularly like to thank all our contributors. A number of friends and colleagues helped by putting together sketches of the women scientists who are no more. This required considerable archival effort, and it was enriching to learn from them of the early days, when the barriers that women needed to cross were huge.

The women scientists who wrote the autobiographical essays have shared their personal stories and insights, and have been most generous with their time. Without them, there would be no book.

Thank you!



1

Edavaaleth Kakkat Janaki Ammal

E K Janaki Ammal
(by C V Subramanian)

Janaki Ammal was born in the year 1897, in Tellichery, Kerala, in a cultured middle class family. Her father was a sub-judge in what was then the Madras Presidency. She had six brothers and five sisters. After schooling in Tellichery, she moved to Madras where she obtained the bachelor's degree from Queen Mary's College, and an honours degree in Botany from Presidency College in 1921.

She then taught at Women's Christian College (WCC), Madras, with a sojourn as a Barbour Scholar at the University of Michigan in the USA where she obtained her master's degree in 1925. Returning to India, she continued to teach at the WCC, but went to Michigan again as the first Oriental Barbour Fellow and obtained her D.Sc. in 1931. She returned as Professor of Botany at the Maharaja's College of Science, Trivandrum, and taught there from 1932 to 1934. From 1934 to 1939 she worked as geneticist at the Sugarcane Breeding Institute, Coimbatore. From 1940 to 1945 she worked as Assistant Cytologist at the John Innes Horticultural Institution in London, and as cytologist at the Royal Horticultural Society at Wisley from 1945 to 1951.

On the invitation of Jawaharlal Nehru, she returned to

India in 1951 to reorganize the Botanical Survey of India (BSI). From then onwards, Ammal was in the service of the government of India in various capacities including heading the Central Botanical Laboratory at Allahabad, and was officer on special duty at the Regional Research Laboratory in Jammu. She worked for a brief spell at the Bhabha Atomic Research Centre at Trombay before settling down in Madras in November 1970 as an Emeritus Scientist at the Centre for Advanced Study in Botany, University of Madras. She lived and worked in the Centre's Field Laboratory at Maduravoyal near Madras until her demise in February 1984.

Ammal was elected Fellow of the Indian Academy of Sciences in 1935, and of the Indian National Science Academy in 1957. The University of Michigan conferred an honorary LL.D. on her in 1956. The Government of India conferred the Padma Shri on her in 1957. In 2000, the Ministry of Environment and Forestry of the Government of India instituted the National Award of Taxonomy in her name in 2000.

In the matrilineal families in Kerala, women normally enjoyed more freedoms and privileges than in many other parts of India. In enlightened families such as Ammal's, girls were encouraged to engage in intellectual pursuits and in the fine arts. Ammal must have been born with a passion for plants which led her to choose to study Botany and go to Madras to do so. Under the influence of teachers at the Presidency College, Ammal's passion sharpened her love of nature and the study of plants in their natural environment.

Her life reflects her experiments in settling for a career and, more importantly, for a mission. First, she took to teaching. Not content, she took to research. Her two innings in Michigan were crucial in determining the choice of her specialization in plant science: she chose cytology which in those formative years of the science was concerned primarily with the nucleus and the chromosomes. The early decades of the last century saw a great deal of pioneering work in genetics, notably on wheat and on sugarcane. At the Sugarcane Breeding Institute at Coimbatore, in the early decades of the last century, C. A. Barber and T. S. Venkataraman initiated research in sugarcane breeding. Venkataraman developed the internationally famous Coimbatore canes such as Co 419 with

qualities of drought-resistance, disease-resistance, etc. The Co varieties were grown in all parts of India and were also preferred for cultivation in other countries where sugarcane was an important crop.

It was in this scenario that Ammal quit her teaching position in Trivandrum and joined the Institute at Coimbatore. Ammal made several intergeneric hybrids: *Saccharum* x *Zea*, *Saccharum* x *Erianthus*, *Saccharum* x *Imperata* and *Saccharum* x *Sorghum*. Ammal's pioneering work at the Institute on the cytogenetics of *Saccharum officinarum* (sugarcane) and interspecific and intergeneric hybrids involving sugarcane and related grass species and genera such as *Bambusa* (bamboo) is epochal. But that was just the beginning of a life in science well lived. During the years (1939–1950) she spent in England, she did chromosome studies of a wide range of garden plants. Her studies on chromosome numbers and ploidy in many cases threw light on the evolution of species and varieties. *The Chromosome Atlas of Cultivated Plants* which she wrote jointly with C. D. Darlington in 1945 was a compilation that incorporated much of her own work on many species.

The focus on polyploidy and evolution of plants which effervesced then continued on her return to India and Ammal now worked on some of the most important genera: *Solanum*, *Datura*, *Mentha*, *Cymbopogon* and *Dioscorea*, besides a range of medicinal and other plants too numerous to be listed here. Ammal was an original thinker and she attributed the higher rate of plant speciation in the cold and humid northeast Himalayas as compared to the cold and dry northwest Himalayas to polyploidy. Also, according to her, the confluence of Chinese and Malayan elements in the flora of northeast India led to natural hybridization between these and the native flora in this region, contributing further to plant diversification.

Following her retirement, Ammal continued to work unabated, focussing special attention on medicinal plants and ethnobotany. She continued to publish the original findings of her research. In the Centre of Advanced Study Field Laboratory where she lived and worked she developed a garden of medicinal plants with great zeal and dedication. Though cytology was her forte throughout her career, her work embraced genetics,

evolution, phytogeography and ethnobotany.

Viewing her life and her work, I would say this of Ammal: From a young age, she was endowed with the courage to make choices and the versatility to change course and adapt where and when required. With her passion for plants, she defined for herself her goals and purpose, and her mission in life. Having done that, she kept her mission above everything else and stuck to it till the end. Crop plants, garden plants, plantation crops, medicinal plants, plants in the wild and plants of the tribals, all species were interesting to her. She just worked on what was on hand and within reach. And, there was much that was on hand and within reach. Her familiarity with British plants was matched by her familiarity with tropical species.

She led a simple life of total dedication to her mission, remaining single. Her physical needs were few and she was unostentatious and modest to the core. To have spent the cruel War years in an alien country in the study of garden plants needed courage of a special kind. When war clouds were on the western horizon to be battered by what Winston Churchill called the “gathering storm,” why did Ammal leave her country to take up a position in Britain? Did she have any support? My conjecture is that India’s freedom fighter in Britain, Krishna Menon, only a year older than her, and her contemporary in Tellicherry and at the Presidency College, Madras, could have been instrumental. Menon may have been the link to her acquaintance with India’s first prime minister, but I have no evidence for this.

She was thoroughly Indian in attire and habits, selfless and Gandhian in her lifestyle. She did not seek favours or the limelight and yet honours came to her unsought; this is true of many great women and men. The honorary LL.D. which the University of Michigan conferred on Ammal in 1956 in recognition of her contributions to botany and cytogenetics said: *Blest with the ability to make painstaking and accurate observations, she and her patient endeavours stand as a model for serious and dedicated scientific workers.*

She lived up to her own definition of greatness which combined virtue in life and passion in the pursuit of her science. There is thus much for us to emulate in her life and work.



2

A heroic struggle of a scientist with cancer

B Vijayalakshmi
(by T R Govindarajan)

Viji joined the Department of Theoretical Physics in 1974 after obtaining her Masters from Seethalakshmi Ramaswami College, Tiruchirapalli. Hers was a conservative background, and it was remarkable that she could overcome conventional gender restrictions and consider research an option.

Our advisor was Professor P. M. Mathews, who was the head of department at that time. Always smiling and friendly, Viji discussed the graduate courses with me like any other student. Once, while we were discussing our work, she expressed some discomfort and I enquired about it. Looking straight at me as if to gauge my reaction, she replied that she had been diagnosed with widespread cancer of the stomach and the abdominal region. I was shocked and speechless for a few moments. Later she told me that her major aim was to make some substantial research contribution and be recognised as a physicist and that her immediate goal was to finish her research degree before anything happened to her.

Both of us were involved in the studies of relativistic equations of higher spin in external electromagnetic and gravitational fields. Our attempts were to look for suitable ways in which

interacting higher spin theories could be constructed. It was a very lively period in the life of the department. There was always much discussion, not only about theoretical physics but also about issues in politics, history, economics and university education. That was also the turbulent period of the Emergency and we came to know of the arrest of many political and trade union leaders.

It was also the time when the Association of Research Scholars of the Madras University was formed. Viji, while concentrating on her research, contributed actively to the Association. Graduate students in the University had to face enormous difficulties, even in routine matters like regular monthly fellowships and the ability to use their contingency or travel grants for their research. Laboratory facilities were poor and students' contingency grants were often used to augment the collections of departmental libraries. Worse still, they had to suffer many unacceptable restrictions from a feudal administrative and academic setup. Viji's involvement in the Association was not liked by some in the University and in the department.

Viji's life and world-view changed after she met T. Jayaraman, who was certainly the most important person in her life. She began to learn about the political scene in the country and to follow political events and happenings closely. She associated herself with the activities of the communist Left as much as her health would allow, an association that grew deeper as the years passed. She also moved on to an atheism that was not always immediately noticeable, but was nevertheless firmly held. Jayaraman and Viji married in 1978; Jayaraman sustained her professional work, gave her courage and inspired her to new achievements, and their marriage and relationship were an inspiration and example to all who knew them. Jayaraman introduced Viji to a circle of friends who became very close to her, and who cared deeply for both of them. With the marriage Viji also acquired concerned parents-in-law who were to assist her diligently in the years of difficult health that were to follow.

All this happened in the midst of many chemotherapy and radiation sessions, which often completely immobilized her. Eventually, as the cancer spread to the bones in her hip and legs,

she had to use a wheel chair for her travel as she could not walk more than very short distances. None of this, however, seemed to affect her good cheer and humour or make a dent on her fighting spirit.

In 1978 she started her work on characterizing a spinning particle in non-relativistic quantum mechanics. This was a novel idea of the interplay of geometry and topology. This also produced an interesting dual relation between massless particles and the monopoles of electromagnetic theory. This work was published and this particular contribution laid the foundation for many interesting developments later.

Her talk at the biannual High Energy Physics Symposium of the Department of Atomic Energy held at the University in Kochi in 1980 was well received. This was a great experience for her. The community of Indian high energy physicists was also very encouraging, treating her with due regard as an upcoming professional. Many of our fellow students, both visitors and those of the University, even took turns to take her around in her wheel chair.

By that time her health began to deteriorate further. Viji was always aware of the race with time. Continuing research for the next couple of years she wrote five publications on the relativistic wave equations in external fields and completed her requirements for Ph.D.. The study of higher spin wave equations and their interactions were important issues which had engaged the minds of physicists and mathematicians. In her thesis work she identified large classes of relativistic equations which were not equivalent to already known equations describing single mass and spin. This study in which she obtained interesting new results involved many conceptually difficult issues in group theory, which she mastered successfully.

This was also the period when supersymmetry was becoming an active area of research among high energy physicists and Viji started actively studying it. She visited IIT Kanpur (IITK) for a couple of months with the active support of her mother-in-law. The physics group at IITK who were watching this wheel-chair-bound researcher were impressed and offered all support for her work. She also met Captain Laxmi Saigal of Kanpur, who was

moved by her courage and arranged support for her health and continued research. Following this she visited the Centre for Theoretical Studies at the Indian Institute of Science, Bangalore (now the Centre for High Energy Physics). She wrote two papers on issues in supersymmetric field theories.

Having accomplished her immediate aim, she continued to be active for two more years, studying relativistic equations from different angles. She even made plans to visit ICTP in Trieste with Jayaraman, but her health deteriorated sharply and she died on May 12, 1985. A socially conscious scientist, she will remain an inspiring figure in the minds of all her friends and associates. An inspiring one-hour documentary of her battle and her spirit, titled "*Vijayalakshmi: The Story of a Young Woman with Cancer*," which also included accounts of her years in school and college, was telecast by Doordarshan in the early 1980s.

Her death was an irreparable loss for all those who knew her. To me she was always truly one of the "*Daughters of Lilavati*."

I thank V K Ramachandran for the photograph of Viji and help in preparing this biographical note.



3

Asima Chatterjee

A Chatterjee
(by S C Pakrashi)

Asima Chatterjee showed early promise obtaining her M.Sc. degree from Calcutta University in 1938, with organic chemistry as the special paper and D.Sc. degree in 1944 from the same university under the guidance of P. K. Bose, the pioneer natural product chemist in India. She was the first woman to be awarded the D.Sc. of any Indian university.

In 1940, Chatterjee joined Lady Brabourne College, Calcutta, as the Founder – Head of the Chemistry Department. In 1944, she was appointed as an Honorary Lecturer in Chemistry, Calcutta University.

She worked with L.M. Parks University of Wisconsin, USA (1947) on naturally occurring glycosides, with L. Zechmeister, California Institute of Technology, Pasadena, USA (1948–49) on Carotinoids and provitamins and with Paul Karrer, N.L. University of Zurich (1949–50) on biologically active alkaloids, which became her life-long interest ever since. After her return to India in 1950, she vigorously pursued investigations on the chemistry of Indian medicinal plants, particularly alkaloids and coumarins.

In 1954, Chatterjee was appointed Reader in the Department of Pure Chemistry, Calcutta University, which became her permanent address almost till her death. In 1962, she became the

Khaira Professor of Chemistry, one of the most prestigious and coveted Chairs of the Calcutta University which she adorned till 1982 and was the first woman scientist to adorn a chair of any University in India. She continued as the Honorary Coordinator of the Special Assistance Programme to intensify teaching and research in natural product chemistry, sanctioned by the University Grants Commission in 1972 and later recognized as the Centre of Advanced Studies on Natural Products in 1985.

Through her untiring efforts, Chatterjee could fulfill her life-long dream to establish a Regional Research Institute for carrying out research on Indian medicinal plants for the development of Ayurvedic drugs along with an Ayurvedic Hospital for systematic clinical trials through a unique Centre-State collaboration, under the aegis of the Central Council for Research in Ayurveda and Siddha in Salt Lake City, Kolkata. As the Honorary Principal Co-ordinator, she nurtured this Institute till the end of her life.

Chatterjee successfully developed the anti-epileptic drug, Ayush-56 from *Marsilia minuta* and the anti-malarial drug from *Alstonia scholaris*, *Swrertia chirata*, *Picrorhiza kurroa* and *Cesalpinna crista*. The patented drugs have been marketed by several companies.

She made significant contributions in the field of medicinal chemistry with special reference to alkaloids, coumarins and terpenoids, analytical chemistry, and mechanistic organic chemistry. She published around 400 papers in national and international journals and more than a score of review articles in reputed serial volumes. Her publications have been extensively cited and much of her work has been included in several textbooks.

Chatterjee edited and revised the six-volume *Bharatiya Banoushodhi* published by the Calcutta University and was also the Chief-Editor of the six-volume series, *The Treatise of Indian Medicinal Plants* published by CSIR.

She was elected a Fellow of the Indian National Science Academy (INSA), New Delhi (1960), received the Shanti Swarup Bhatnagar Award (1961) and was conferred Padma Bhushan (1975) amongst other awards. She was elected as the General President of

the Indian Science Congress Association (1975) the first woman scientist to be so elected, and was nominated by the President of India as a Member of the Rajya Sabha which she served with distinction from February 1982 till May 1990.

She probably imbibed interest in the medicinal plants from her father, Dr. Indra Narayan Mukherjee, a medical man cum amateur botanist. During her post-graduate studies, she came in contact with eminent teachers and educationists such as, Acharya P. C. Ray, P. C. Mitter. P. Ray, P. B. Sarker, J. N. Mukherjee, P. K. Bose and J. C. Bardhan all of whom influenced her future career.

Being one of her early Ph.D. students I have closely witnessed her initial struggles to establish herself. Those were trying days for research, particularly in the most ill-equipped university laboratories with inadequate chemicals and meager financial assistance. DST, DBT were yet to come and CSIR was in the formative stage. Research guides had often to pay not only for chemicals, apparatus, etc., but also the charges of even elementary and almost all spectral analyses to be had from abroad. Scholarships were few and barely enough; most of the students had to work part time or without any scholarship just for the love of work and pay all the necessary cost of thesis submission including printing, examination fee and even the postal charges for dispatching the thesis to the foreign examiner(s) which was compulsory, with hardly any job prospect for research as a profession.

Before I joined her, she had a grant of Rs 300/- p.a. and three college teachers as part time research students. I was the sole fulltime scholar with laboratory grant of Rs. 1000/- p.a. only with a princely W. B. Govt. stipend of Rs.150/- p.m. For milling plant materials we had to go to the far away workshop of the Jadavpur University and even for UV measurement, we had to go to adjacent Bose Institute where only she was allowed to handle the equipment. We borrowed solvents for plant material extraction mostly from the comparatively well off B.C. Guha's laboratory as the research grant of even the Heads of Departments used to be only Rs. 1200/-.

During those hard days, she received encouragement from Profs. Satyen Bose, Meghnath Saha, S. K. Mitra , B. C. Guha and

Sir J. C. Ghosh and other Vice-Chancellors of Calcutta University. Her husband, Professor Baradananda Chatterjee, a renowned Physical Chemist himself and the Vice-Principal of the then Bengal Engineering College (now a Deemed University), Sibpur, Howrah, solidly stood by her. She in turn could inspire and keep the morale of her students by her own example. Nevertheless, she was a very hard task master, never satisfied with performance and would never compromise with the standard of work. "I wish to work as long as I live", her philosophy and work culture that she followed in letter and spirit.



4

Anandi Gopal

Anandibai Joshi
(by Pooja Thakar)

In 'lot 216-A' of the Poughkeepsie Rural Cemetery, New York, amongst the numerous gravestones of Americans lies the rectangular gravestone of Dr. Anandibai Joshi. The inscription tells us that Anandi Joshi was a Hindu Brahmin girl, the first Indian woman to receive education abroad and to obtain a medical degree. How did she achieve this? What were the obstacles she faced? I try below, to give my version of what her answers might have been to these questions today, based on information gathered by reading about her and her times.

I was born on 31st March, 1865 as Yamuna Joshi in Kalyan, a small town near Mumbai. My family used to be the land lords in Kalyan, but had lost their riches. I got married when I was 9 years old and my name was changed to Anandi.

Before my marriage, I could manage to read Marathi; education of girls was not common then. But my husband, Gopalrao, was an ardent supporter of widow remarriage and women's education. In fact, he married me on the condition that he would be allowed to educate me. After our marriage, he started teaching me. This was very difficult; in those days, a husband didn't even speak directly to his wife in front of others. In the beginning, my husband tried to enroll me in the missionary schools, but that did not work out. We had to move from Kalyan to Alibaug to Kolhapur to Calcutta. Once I started learning, I was soon also able to read

Sanskrit and also read and speak English.

Learning from my husband was not an easy task. He would hit me with pieces of wood; throw chairs and books at me in anger. I remember him threatening to leave me when I was 12. Years later, when I wrote to him from America, I asked him whether this was right. I had always wondered if it was good behaviour on his part. What would have happened, for instance, if I had left him then? I explained to him in the letter that I would always be grateful for what he had done for me. But at the same time, I couldn't help but wonder how a Hindu woman had no choice but to allow her husband to do what he wished.

After my rapid progress, my husband was insistent that I should acquire higher education. I realized that most women in our country had no access to female doctors, and women who were ashamed or reluctant to approach a male doctor would suffer a lot as a result. I myself had lost my infant son when I was 14. So I decided that I would be a doctor. Even the subject I picked for my thesis later was "Obstetrics among Aryan Hindoos".

My husband tried hard to get me admission to some university in America. He even tried to pretend becoming a missionary to that end but it invited only ridicule. However, a Mrs. Carpenter of Roselle, New Jersey, came to know the story by chance and was moved by the correspondence in the *Missionary Review*, and wrote me a letter. She offered to host me, and soon Mrs Carpenter and I started writing to each other a lot. I felt very close to her and started calling her 'mavashi' (aunt). In these letters, we discussed various issues; I could write to her about my wonderings on matters which I don't think I could have expressed in public. We discussed early marriages and how they affected women's health. I recall, in one letter to her I wrote about how a legislation similar to the suttee ban would be desirable in case of child marriage too. Similarly we discussed the status of women in the society.

Since Gopalrao wasn't able to get a job there we decided that I should leave for America alone. We had to face a lot of opposition and criticism, to the extent of people throwing stones and cow dung at us. Finally after many trials and tribulations, in June 1883, I reached America escorted by American missionary women, and was met by my Carpenter mavashi.

In America there were many things that I thought were strange and many that the Carpenters found strange about me. But Carpenter mavashi took care of me as if I was her daughter. She cried like a child when she left me at the Women's College in Philadelphia.

The Superintendent and Secretary of the College were very kind and were impressed that I had come to study from so far away. They even offered me a scholarship of \$600 for the three years I would be there.

The first problem I faced in America was the attire for winter. The traditional Maharashtrian nine yards saree I wore left my waist and calves uncovered. Wearing western attire, better equipped to handle cold, was not something I was completely comfortable with. At the same time, I remembered the verses I had read in the Bhagwad Gita which said the body is just a covering for the soul which could not be corrupted. I felt if this was true, then how would my wearing western clothes corrupt or destroy my soul? After much debate and wondering, I decided to wear the saree like the Gujarati women wore; I would cover my waist and calves and could also wear a petticoat inside. I decided not to inform Gopalrao as yet.

However, the room that was provided to me at the college didn't have a proper fireplace. The fireplace emitted a lot of smoke when lit. So it was a choice between smoke and cold! My health was severely affected by my stay there. After around two years in the U.S.A., I had sudden spells of faintness and high temperature. The cough never left me. By the end of the three years, my condition had worsened. I somehow scraped through the final exams.

At the convocation where my husband was present and so was Pandita Ramabai, it was announced that I was the first woman doctor of India and got a standing ovation for that! It was one of the most rewarding moments of my life. My health, however, grew worse day by day. My husband admitted me to the Women's hospital in Philadelphia and I was diagnosed as having Tuberculosis. But the disease hadn't yet reached my lungs. The doctors advised to go back to India. I decided to do that, and accepted the offer for the post of Lady Doctor in Kolhapur"

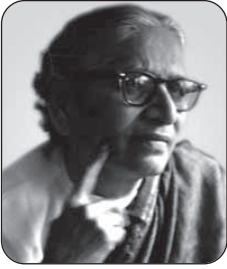
The journey back home took a further toll on Anandibai's health as doctors on the ship refused to treat a brown woman. On reaching India, she stayed at her cousin's place in Pune to receive treatment from a renowned Ayurvedic specialist who also refused to treat her as according to him, she had crossed the boundaries of society. Finally on February 26th, 1887, Anadibai succumbed to her disease at the age of 22. She was mourned throughout India. Her ashes were sent to Mrs. Carpenter who placed them in her family cemetery in Poughkeepsie.

It is incredible how far the 15-year-old Anandibai had reached in her perception of the society then. Her letters to Mrs. Carpenter show that she had formed her own opinions on issues that today would be considered feminist. Feminist writings like Tarabai Shinde's 'Stree Purusha Tulana', Pandita Ramabai's 'Stree Dharma Neeti', and Rakhmabai's letters under the name 'The Hindu Lady' to the Times of India also date from the same period. It is amazing that Anandibai was just 15 when she held very similar opinions.

Anandibai's efforts however, were not in vain. To this day, she inspires Indian girls from all walks of life and enables us to believe that whatever the circumstances, nobody's dreams are unachievable and that each of us has the potential to achieve what we wish to. Today the Maharashtra government has a fellowship in her name for young women working on women's health.

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5

Not so quiet has flown the Iravati

Iravati Karve
(by Jai Nimbkar and Varsha Kelkar–Mane)

The name Iravati is rather unusual, but then her whole life was unusual. The daughter of Hari Ganesh Karmarkar was born in Burma in 1905 when he was working as an engineer there and was named after the river Irawady.

At the age of seven she was sent to India for schooling to Huzoor Paga, a boarding school for girls (and one of the first schools for girls in Maharashtra), in Pune. There she made friends with a classmate, Shakuntala Paranjpye, daughter of Wrangler R. P. Paranjpye. Shakuntala's mother took Iravati to stay with her family: this was to change the course of her life. At this intellectual, atheistic household, she was exposed to a wide range of books and people, one of whom was judge Balakram, who instilled in her an interest in anthropology, a field in which she was to work and leave her mark. It was during this period that she met and later married Dinakar Karve, a Professor of Chemistry in the Fergusson College, Pune, the second son of Maharshi Dhondo Keshav Karve, one of the pioneers in the field of women's education and widow remarriage in the country.

After her B.A. from Fergusson College, Iravati got an M.A. in sociology under the guidance of Dr. G. S. Ghurye, the founder

of the department of sociology in Bombay university. Her husband, who had realized her intellectual ability, decided that she should study abroad in order to realize her full potential. She accordingly went to Berlin and obtained a Ph.D. in anthropology under the guidance of Prof. Eugen Fischer, Director of the Kaiser Wilhelm Institute for Anthropology, Eugenics and Human Heredity in 1930.

After returning to India, she worked for a brief period as Registrar of S.N.D.T. College in Pune. Her real interest, however, lay not in the administrative field but in scientific research and the academic field. She eventually accepted a post in the Deccan College Post-graduate Research Institute, and spent her entire professional life working in her chosen field under the aegis of this institute.

The main problems she addressed in her work were, "What are Indians? Why are we what we are?". The goal she thus set for herself was very much in line with the general aims and objects of anthropology. Specific questions she sought answers to were i) whether more detailed cultural and physical configurations can be established in India in terms of historical, proto-historical folk movements, ii) What were the physical features of the people who were responsible for the numerous historic and proto-historic sites found all over India, iii) What is caste? To find answers to such questions, her approach was ethno-historical, perhaps the result of her training in Berlin. She started simultaneous investigations in four inter-disciplinary branches: Paleo-anthropology, indological studies, epics and oral traditions, systematic physical anthropological investigations in various regions, and detailed sociological studies in different linguistic areas.

Iravati Karve felt that instead of haphazardly taking measurements of the people of India as a whole, a systematic study of the people of one limited region would be more significant for finding out the racial composition of a cultural region. She was not in favour of taking measurements of primitive groups or caste groups. She said that, for instance, a sample of a hundred subjects from the Maharashtrian Brahmins could not give an idea of the gene pool of the twelve endogamous sub castes of the Brahmins.

The two prominent Brahmin sub-castes, Chitpavans and Deshastha Rigvedi, are quite different from each other, and the latter is much closer to Marathas. She therefore strongly advocated that sampling for the Indian population should be done at the caste level and not the caste-cluster level. This concept of caste as a unit of study and a research tool has revolutionized Indian anthropology.

Dr Karve also studied kinship terms and usages and family organization in the Rigveda, Atharvaveda and Mahabharata. She collected data from Gujarat, Karnataka, Orissa, Kerala, Tamilnadu and Uttar Pradesh. The results of these studies were organized into a book 'Kinship organization in India' (1953). This work which has run into three editions, is a classic in cultural anthropology and a basic source book for scholars wishing to work in this field.

Her work brought her recognition in India and abroad. She was elected President of the Anthropology section of the Indian Science Congress in 1947 and was offered a lectureship in the School of Oriental and African Studies at London University.

Her most important contribution includes a number of books such as 'Hindu Society, an Interpretation', in which she has presented a fresh interpretation of the caste structure, 'Kinship Organization in India', and 'Maharashtra, Land and People'. She has also written 'Yuganta', a critique, in Marathi, on the Mahabharata, which earned her the Sahitya Akademi award. Her unorthodox interpretation of various characters hurt the sentiments of some traditionalists, but the book became vastly popular. It has been translated into various Indian languages as well as into English, and is still going into new editions over thirty years after her death in 1970.

Iravati Karve died in her sleep on August 11, 1970 at the age of sixty five. She brought to her scholarship a combination of intellectual integrity, tremendous mental energy and an ability to find a rapport with a wide range of people, and left a permanent mark on learning and literature in modern India.



6

An appreciation of Anna Mani

Anna Mani
(by Abha Sur)

Anna Mani grew up in a prosperous family in the state of Travancore, a former princely state in the Southern part of India, now part of Kerala. Born in 1918, she was the seventh of eight siblings. Anna Mani's father was a civil engineer with large cardamom estates to his name. The family belonged to the ancient Syrian Christian church; however her father remained an agnostic throughout his life.

The Mani family was a typical upper-class professional household where from childhood the male children were groomed for high-level careers, whereas the daughters were primed for marriage. But Anna Mani would have none of it. Her formative years were spent engrossed in books. By the age of eight, she had read almost all the books in Malayalam at her public library and, by the time she was twelve, all the books in English. On her eighth birthday she declined to accept her family's customary gift of a set of diamond earrings, opting instead for a set of Encyclopedia Britannica. The world of books opened her to new ideas and imbued in her a deep sense of social justice which informed and shaped her life.

In 1925, at the height of the Vaikom Satyagraha where people of all castes and religions across Travancore protested the

decision by the priests of a temple in the city of Vaikom to bar dalits from using the road adjacent to the temple, Mahatma Gandhi came to Vaikom to lend his support to the civil disobedience movement. The motto of the satyagraha, 'one caste, one religion, and one god for men [sic]' became the rallying cry of the progressives who demanded that all Hindus irrespective of their caste be allowed entry into the temples of the state. The satyagraha, and especially Gandhi's visit, made a deep impression on young and idealistic Anna.

In subsequent years, as the nationalist movement gained momentum and the Indian National Congress adopted complete independence as its goal, Anna Mani became increasingly drawn to nationalist politics. Although she did not join any particular movement, she took to wearing only khadi as a symbol of her nationalist sympathies. A strong sense of nationalism also reinforced in her a willingness to fight for a fiercely desired personal freedom. When she insisted upon pursuing higher studies instead of following in the footsteps of her sisters, who got married in their late teens, there was neither active opposition nor encouragement from her family.

Anna Mani had wanted to study medicine, but when that was not possible she decided in favor of physics because she happened to be good in the subject. Anna Mani enrolled in the honors program in physics at the Presidency College in Madras (now Chennai). In 1940, a year after finishing college, Anna Mani obtained a scholarship to do research in physics at the Indian Institute of Science and was accepted in C.V. Raman's laboratory as a graduate student. In Raman's laboratory, Anna Mani worked on the spectroscopy of diamonds and rubies. During this period Raman's laboratory was immersed in the study of diamonds because of Raman's ongoing controversies with Max Born on crystal dynamics and with Kathleen Lonsdale on the structure of the diamond. He had a collection of three hundred diamonds from India and Africa and practically all his students worked on some aspect of diamonds.

Anna Mani recorded and analyzed fluorescence, absorption, and Raman spectra including the temperature dependence

and polarization effects of over thirty different diamonds. The experiments were long and painstaking: the crystals were held at liquid air temperatures, and the weak luminescence of some of the diamonds required fifteen to twenty hours of exposure time to record the spectrum on photographic plates.¹ Anna Mani spent long hours in the laboratory, sometimes working through the night.

Between 1942 and 1945, she published five papers single-authored on the luminescence of diamonds and rubies. In August 1945 she submitted her Ph.D. dissertation to Madras University and was awarded a government scholarship for an internship in England.

However, Anna Mani was never accorded the Ph.D. degree she so rightly deserved. Madras University, which at that time formally granted degrees for work done at the Indian Institute of Science, claimed that Anna Mani did not have a M.Sc. degree and therefore she could not possibly be granted a Ph.D. They chose to overlook that Anna Mani had graduated with honors in physics and chemistry, and had won a scholarship for graduate studies at the Indian Institute of Science on the basis of her undergraduate degree. To this day her completed Ph.D. dissertation remains in the library of Raman Research Institute, indistinguishable from other bound dissertations, with no indication that Anna Mani's dissertation did not result in a degree for her. Anna Mani, however, bore no grudge against this miscarriage of justice and insisted that lack of a Ph.D. degree made little difference in her life.

She left for England soon after finishing her research work in Raman's laboratory. Although her preference had been to pursue research in physics, she ended up specializing in meteorological instrumentation as it was the only scholarship available to her at that time.

Anna Mani returned to independent India in 1948 and joined the Indian Meteorological Department at Pune. At the department, Anna Mani was in charge of construction of radiation instrumentation. In a career of almost 30 years, she published a number of papers on topics ranging from atmospheric ozone to the need for international instrument comparisons and national

standardization of meteorological instrumentation, retiring as Deputy Director General of the Indian Meteorological Department in 1976. She subsequently returned to the Raman Research Institute as a visiting professor for three years.

She published two books, *The Handbook for Solar Radiation Data for India* (1980) and *Solar Radiation over India* (1981), and worked on several projects for harnessing wind energy in India. Later, in the industrial suburbs of Bangalore, Anna Mani started a small company that manufactured instruments for measuring wind speed and solar energy. Anna Mani believed that the development of wind and solar energy in India required detailed knowledge of solar fluxes and wind patterns in different regions of India, and it was her hope that the instruments produced in her factory would have wide utility in procuring this information.

However, despite her interest in and involvement with environmental issues, Anna Mani never saw herself as an environmentalist (“carpet baggers” as she called them) who seemed to be “always in orbit.” She preferred to stay in one place.

Anna Mani had a very matter-of-fact view of her life and achievements. She saw nothing unusual in her pursuing physics in an era where it was possible to count all women physicists in India on one’s fingertips. She made light of the difficulties and discrimination she encountered as a woman scientist and was disdainful of victim politics. She actively resisted coercive gender identities which limited women’s potential as well as posited different intellectual capabilities in men and women.

It is no surprise that Anna Mani’s is a success story to which few women (or men) could aspire. She transcended the limited cultural spaces available to her and not only created a room of her own, and a laboratory of her own but a whole workshop, a mini factory of her own.



7

Obsessed with excellence

Kamal Ranadive
(by R Bhisey)

Kamal Samarth was born in Pune in 1917. Her father taught biology at Ferguson College, Pune and ensured that all his children, including his daughters, were well educated. Of all his children, Kamal was the brightest. She went to a girls high school 'Huzurpaga: the H.H.C.P. High School for girls' and studied botany at Ferguson College. Further she joined the Agriculture College, Pune where she worked on the cytogenetics of annoneaceae for her Master's degree. Following her marriage to J.T. Ranadive, Kamal Ranadive moved to Bombay close to Tata Memorial Hospital which brought her in contact with V.R Khanolkar, a renowned pathologist and great visionary, who founded the Indian Cancer Research Centre. Kamal worked under his guidance for the Ph.D. degree from the University of Bombay.

After a post doctoral stint in the laboratory of George Gey who developed the HeLa cell line at Johns Hopkins University Hospital, Kamal Ranadive returned to India and established the first tissue culture laboratory at the Indian Cancer Research Centre. In the early 1960s tissue culture media and other reagents had to be prepared in the laboratory. To fulfill these needs Dr Ranadive recruited a team of biologists and bio chemists.

Quick to recognize talent, sincerity and integrity in her colleagues and students, Kamal Ranadive encouraged them to work in various areas of cancer biology. She strongly believed that scientists who went abroad for postdoctoral work should return to India and develop new areas of research in their perspective laboratories. A staunch nationalist, she instilled the same spirit in her colleagues, enough that most of them returned to work in India, making Cancer Research Institute a renowned centre for cancer research. Her unique quality for allowing individual scientific talents to bloom, in fact resulted in the formation of three new divisions, carcinogenesis, cell biology and immunology besides tissue culture.

Her work on animal models for understanding patho-physiology of cancer was extremely important. She was among the first to recognize the connection between cancer susceptibility and interaction between hormones and tumor virus. The so called Indian Cancer Research Institute (ICRC) mouse studied by her group turned out to be an excellent model for work on leukemia, breast cancer and cancer of oesophagus. In addition to this she continued her work on leprosy bacteria, which eventually led to the preparation of a Leprosy vaccine.

Dr Ranadive, fondly addressed as “Bai” by her colleagues and students had an imposing personality. A strict disciplinarian, she instilled the spirit of hard work in her students; her lab was busy till late in the night! She was the recipient of many awards including Padma Vibhushan and the Watumal Foundation award for her work in the field of leprosy.

She founded the Indian Women Scientist Association (IWSA) with the goal of spreading science to masses particularly women and children. IWSA, a hostel for working women and a building that houses a community centre besides IWSA office, continues to hold many activities even today. After her retirement, Dr Ranadive worked on the nutrition and health of tribal women and children in Rajur in Maharashtra. This project was a huge success, providing awareness about nutrition and medical care to tribals and training women health workers as primary health care givers.

Those of us who were fortunate to know Dr Ranadive closely recall her generosity and hospitality. Discussions would always veer to science, new ideas, achievements and what needed to be pursued and was relevant to the country's need. I did not work under her although my husband was her doctoral student and later a colleague. I came to realize her total sincerity and commitment to science when she visited us in Philadelphia in 1969. Before the visit, she had asked us to invite Indian post-docs with whom she could have an informal chat. The reason was obviously to find out if any of them would return to India.

How would one remember this somewhat private, yet warm hearted and highly revered daughter of India? With her generosity, integrity and obsession with advancement of excellence in science, Dr Ranadive made an indelible impression on my mind.



8

She was a star

Darshan Ranganathan
(by S Ranganathan)

Darshan Ranganathan was born on June 4, 1941 and passed away from metastasis of cancer on June 4, 2001, exactly at the age of sixty.

Darshan! I often said, “You are a star”!

She was more than that. She was a comet on the chemical horizon, shedding brilliance at prodigious costs of energy and vanishing at the apex of her career.

In describing Darshan’s personality, I will begin with, what many may consider a hyperbole. With her expensive Canjeevram saris and the big red *bindi* on her forehead, she always appeared elegant to the extent that after one of her lectures at a symposium in Bangalore, a German professor commented that she reminded him of a picture of an Indian Goddess! We all laughed at that time but I think this statement in fact summarized everything about Darshan; her great warmth, quiet dignity, humility, equanimity and fortitude.

Summarizing Darshan’s genius is difficult. At the time of her passing away, she was the most prolific organic chemist in India, having, in the last five years, a dozen publications in The Journal of the American Chemical Society, six in the Journal of Organic Chemistry and dozens in others. Her monumental contribution to the Accounts of Chemical Research was published, as

well as many other papers, posthumously. She was elected Fellow of the Indian Academy of Sciences, Indian National Science Academy and the recipient of many honors the last of which was The Third World Academy of Sciences Award in chemistry for her outstanding contributions to bio-organic chemistry, particularly supramolecular assemblies, molecular design, chemical simulation of key biological processes, synthesis of functional hybrid peptides and synthesis of nanotubes, in 1999.

All these achievements assume special significance, particularly for young women aspiring scientists in India, when viewed from the fact that at every turn in her life she felt the impact of male chauvinism that so controls the scientific world. She fended them all with the invincible armour of obsession for scientific research. When she came to Kanpur, where I was a member of the faculty, the unwritten rules that exist even today, did not permit her to be offered a position. Therefore, throughout her long stay in Kanpur, she had to hop from fellowship to fellowship and for some periods none at all! We count on small mercies and both of us were truly grateful to IITK and the chemistry department for permitting her to do research.

I knew from the beginning that she was better than me and was proud to share my funds and students with her so that she could work on her own problems and publish on her own. That was all she wanted, brushed away all other irritations and slowly blossomed into an organic chemist who won international peer recognition, even before she accepted an independent position at RRL, Trivandrum in 1993 and subsequently moved to ICT, Hyderabad in 1998.

Darshan was born to Shanti Swarup and Vidyavati Markan in 1941. I have heard, although she has vehemently denied it, that when young, she was quite a naughty girl with love for singing, drawing and dancing, the latter she performed once on the teacher's table! Darshan received her early education in Delhi and secured her Ph.D. from Delhi University under the guidance of Professor T.R. Seshadri. During this period she was a lecturer in chemistry at Miranda College, Delhi and rose to the rank of the Head of the Chemistry Department. Her academic record was truly out-

standing. As a coveted awardee of Senior Research Scholarship of the Royal Commission for the Exhibition of 1851, she carried out outstanding postdoctoral work in the group of Professor D. H. R. Barton. She returned in 1969, married in 1970 and started her independent research at the Indian Institute of Technology, Kanpur, the very same year.

Her perception of problems were truly uncanny. Some of Darshan's most notable work was on supramolecular chemistry. She became a wizard in conjuring supramolecules at various shapes. These important biomolecules made by aggrandization of smaller units play an important role in Nature. Her contribution to chemical education was monumental. She co-authored several books and a generation of young organic chemists grew up with "Current organic chemistry highlights", edited by Darshan and myself (those days, I typed on a stencil and she drew the structures beautifully). Our life was in perfect resonance; both of us worked unbelievably long hours and each of us were mostly engrossed in our own research areas.

For such a wonderful human being, that the end should come early and painfully is indeed a cruel twist of irony. Her breast cancer was detected in 1997 and she went through all the treatments including mastectomy and radiation. She had regular check-ups. But the vicious infliction returned and in spite of all possible treatments, proved futile. She fought the long suffering just as bravely. She passed away the very day she was born sixty years ago and to the very day and time to the minute we were married 31 years ago!

What Darshan faced at Kanpur to pursue her research would continue for a long time and one could win this battle only with determination. A very useful strategy for aspiring women scientists in India, is to adopt the approach taken by Darshan, who realized that women scientists will face additional impediments and planned her career taking note of this rather than worrying about it. She set an example to emulate. Till the very end of her life she worked very hard. Her courage and will to fight with no acrimony and with a smile and verve were really special.

As a small tribute to Darshan's fierce profile, The Indian

National Science Academy kindly agreed to institute a biennial lecture in her memory to an outstanding woman scientist regardless of the domain of research. This is a first for the Academy to offer encouragement to women scientists, which has been overdue.



9

The scientist lady

Kamala Sohonie
(by Vasumati Dhuru)

Kamala Sohonie was a quiet, unassuming person. A woman of few words. To look at her one would think that the stream of her life also must have been quiet, easy, uneventful. It was not so, she had many hurdles to cross. Many rapids to pass, before she could be known as a 'Woman in Science'. That too when she had full support from her family.

Little Kamala (Bhagwat) was very fat. She had an uncle who was a renowned chemist and also very fat. So the young fat girl decided that she was destined to be a renowned chemist. Her father Narayanrao Bhagwat and his brother Madhavrao were distinguished chemists too. They were among the first to pass out from (Tata) Institute of Science, Bangalore. Therefore after passing her B.Sc (physics and chemistry) from Bombay University and having stood first (in first class) in that exam, she thought that doing research work at that famous institute was a matter of course. She then applied for admission there and received a prompt refusal. The reason cited being that she was a woman. The illustrious director of the institute, Sir C.V. Raman, Nobel Laureate, did not think a woman scientist, to be research material!

Kamala refused to accept this refusal based on gender bias. A firm believer in Mahatma Gandhi, she decided to do Satyagraha

in Raman's office, till she was admitted. Prof. Raman granted her admission on condition that for one full year she would be on probation; meaning that she could work but that work would not be recognized until the director was satisfied about its quality and also that her presence did not distract his male researchers from their work. Kamala accepted these terms, but one can only imagine her indignation at them. The first hurdle in her pursuit of science was crossed (1933).

At the Institute of Science, Bangalore, she worked very hard under her teacher, Shri Sreenivasayya. He was very strict, demanding and at the same time eager to impart knowledge to deserving students. After observing her for a year, Raman was satisfied about her sincerity and discipline. She was allowed to do regular research in Bio-chemistry. He was impressed enough to admit lady students to the institute from then on. This was another victory for Kamala, and through her for other aspiring Indian women scientists.

Here she worked on proteins in milk, pulses and legumes, which in fact had important implications for nutritional practices in India. In 1936, Kamala, then only a graduate student, was the first person to work on pulse proteins. She submitted her research to Bombay University and received her MSc degree. She went then to Cambridge University and first worked in the laboratory of Dr Derik Richter who offered her a spare table to work during the day, where he himself would at night when she left.

When Dr Richter left to work elsewhere, Kamala continued her work under Dr Robin Hill, who was doing similar work, but on plant tissue. Here, working on potatoes she found that every cell of plant tissue also contains the enzyme "cytochrome C" and that cytochrome C is involved in oxidation of all plant cells. This was an original discovery embracing the entire plant kingdom.

Kamala sent a short thesis describing her finding of cytochrome C in respiration of plant tissue, to Cambridge University for her PhD degree. Her PhD degree is remarkable in many ways. Her research and writing of the thesis was done in less than 14 months since arriving at Cambridge. It consisted only of 40 typewritten pages. Those of others sometimes contained more than

thousands of pages. She was the first Indian woman “on whom the title of PhD degree was conferred”.

She was keen on returning to India, and started work at Lady Hardinage College, New Delhi, 1939 as professor and head of the newly opened Department of Bio-chemistry. Later she was Assistant Director of the Nutrition Research Lab, Coonoor. There she conducted important research on the effect of vitamins. However, due to lack of clear avenues for career advancement, (which need not be attributed to gender bias but the possibility cannot be ruled out), she started thinking of resigning. Around this time, she received a proposal of marriage from Mr M V Sohonie, an actuary by profession. She accepted the proposal and moved to Mumbai in 1947.

The Govt of Maharashtra invited applications for the post of Professor of Bio-chemistry in the newly opened Bio-chemistry Department at their (Royal) Institute of Science, Bombay. Kamala applied and was selected. During her tenure at the Royal Institute, she worked with her students on nutritional aspects of Neera, pulse and legume proteins as well as Dhan (paddy) atta. All the subjects of her research were very much of relevance to Indian Societal needs. In fact, her work on Neera was started on a suggestion from the then Rashtrapati Dr Rajendra Prasad.

Further, she also advised the administration of the Aarey Milk project on improving the quality, one can count names of many distinguished scientists among the list of students she trained. Her work conducted by her students showed that introduction of Neera in the diet of tribal malnourished adolescent children and pregnant women, caused significant improvement in their overall health. She made her students (different batches) do this work on samples of neera taken from all over the country. They worked for 10-12 years and always got the same results. Kamala Sohonie received the Rashtrapati Award for this work.

Even here at the Institute of Science, Bombay, she was kept away from her rightful position as Director of the Institute for four full years (maybe due to internal politics). When finally she was given that post, Dr Derik Richter, her first guide at Cambridge, remarked that she “made history by being the first lady Director of such a big science institute.”

In conclusion, Kamala Sohonie lived a full life. She was successful in her chosen career, as a research scientist, and as a teacher.

When Dr Satyavati, then Chairperson of Indian Council of Medical Research (infact the first woman DG of ICMR) learned of Kamala Sohonie and her work she decided to make amends. She invited Kamala, who was then 84 and felicitated her in an impressive ceremony in New Delhi. Ironically, at this ceremony, Kamala Sohonie collapsed. What better end could one wish for?



10

Return to the mainstream: The torturous track

Radha Balakrishnan

In 1957, when I was thirteen, I had just entered Std. IX in a co-educational school in New Delhi. The Delhi Board required a student to branch off into either the sciences or the humanities at that early stage. The science group was sought after because of better job prospects. Owing to the shortage of lab space, entry was restricted to students with marks above a cut-off.

I was among them, and chose the science group. The principal addressed our class, and urged the girls who had opted for science to give up their seats in favour of boys with lower marks. The girls, he said, were depriving those boys of good jobs in the future – because the only jobs that the girls would ever take up after getting married would be in the ‘ladle-office’ (the kitchen). I don’t remember my reaction to this sarcasm, but the principal was merely echoing the mindset of the times. He presumably felt that he was giving the girls good advice, with their future happiness in mind. But I had always enjoyed and done well in the science-related subjects I’d been taught till then, and was quite sure I wanted to continue studying science.

This was my rather tremulous entry into science, with a probable future in the ladle office looming large. I did well in the

Board Exam in 1960 and got admission to Physics Honours at Delhi University, a course reputed to be challenging and among the very best in India. Very few women even applied for it. Well-meaning family friends whose sons had taken this course opined that, as a woman, I would feel extremely isolated and hence find the course even tougher. But as I had always found physics to be interesting and enjoyable, I joined the course, and went on to complete my M. Sc. in 1965. By this time, many of the girls among my classmates in school and college were married. My parents might have liked to see me similarly settled, but when I wanted to do my PhD in the US, they gave me unstinting support and encouragement. They were exceptionally broad-minded and liberal, and I am eternally grateful to them.

I worked for my Ph.D. at Brandeis University, and in 1970 defended my thesis (one of the very earliest studies of quantum crystals) on the effects of helium four impurities in solid helium three. My adviser, Prof. Robert Lange, gave me constant encouragement and full freedom to try out my ideas and also offered to arrange for a postdoctoral fellowship in the US. When I told him of my decision to return to India, his prescient words were: "As a woman physicist, you will need to produce twice as much work as a man to get half the recognition. The prejudice and chauvinism of many men (no matter where they are from) towards women physicists is appalling." I shall not describe the struggles during the decade that followed in trying to stay active in theoretical physics by publishing papers from home, while coping with raising children and the formidable difficulties encountered in finding employment commensurate with one's qualifications, without breaking up the family.

Let me 'fast forward' to the 1980s. I am sincerely grateful to Prof. P. M. Mathews, for enabling me to work at the Department of Theoretical Physics, University of Madras, from early 1982 to early 1987 as a Research Associate (CSIR and UGC), and to Prof. E. C. G. Sudarshan, (then) Director, IMSc, for his support which led to my permanent position there in early 1987.

Around 1980, I had started studying nonlinear phenomena and solitons, and this became my major research interest in

the succeeding years. At IMSc, I worked on the applications of solitons and the inverse scattering method to classical and quantum magnetic chains, superfluid helium, geometric phases associated with moving curves, etc. I got Fulbright grants for visits to Los Alamos National Lab, became a Senior Associate at ICTP, Trieste, and held CNRS visiting professorships in France. I have had the opportunity to collaborate with physicists from China, England, France, Poland, and the USA, in addition to colleagues, students and postdocs in India. From the 1990s, I have been studying the deep connections between nonlinearity and the differential geometry of curves and surfaces. I received the Tamil Nadu Scientists Award in the Physical Sciences (1999) for this work, and INSA's Professor Darshan Ranganathan Memorial Lecture Award (2005) for original and pioneering contributions in nonlinear dynamics.

In spite of setbacks and grave disappointments, my life as a researcher in physics has been extremely enjoyable. After my formal retirement in 2004, I am actively continuing my research at IMSc as a CSIR Emeritus Scientist. Over the years, things have changed considerably, and for the better. The RA schemes of the CSIR, UGC, etc. serve a vital purpose. The title of this article has been inspired by a recently-introduced scheme of the DST, offering fellowships to women scientists with a career break who desire to return to mainstream science.

To all those talented young women who love physics but are hesitating to take it up, I have this to say. People like you are needed to bring in new ideas to solve the many fascinating and challenging problems in diverse areas of physics today. Motivation is as important as innate intelligence to succeed in creative research. When the going gets tough (as it surely will), hold your head high, work hard, and do not give up! Take inspiration from the heroic lives of Sophie Germain, Ada Lovelace, Sonya Kovalevskaya, Marie Curie, Lise Meitner, Emmy Noether, Cecilia Payne-Gaposchkin and Maria Goeppert-Meyer.

The joy that one derives out of original research, however small one's contribution may be, cannot be explained in words. It has to be experienced.



11

Why I became a scientist

Bindu A Bambah

Environmental influences play a crucial role in women's participation in the sciences. The stress on mathematics and science in school is perhaps the earliest influence in choosing a career in science. The men and women who teach girls influence their perception about whether or not women can be successful in science.

I was very lucky because I had a number of positive role models in my school years by having teachers who were very encouraging and who awakened my scientific perceptions. The first contact I had with the scientific method was in 1967, at the age of 10, the year when Dr. Christian Barnard performed the first heart transplant. Our teacher, Ms. Jessica Keller, an avid science enthusiast, brought a pig's heart into class and explained the procedure to us. It was truly amazing. Then, in 1969, the first moon landing occurred and we were taken to see the moon rocks. The world of outer space inspired me to study the physical aspects of nature.

Later in high school, our physics teacher, Sister Vincent, introduced us to quantum mechanics, with all its scientific mystery. Our chemistry teacher, Mr. Pyaara Singh, told us the tale of Kekule's snake to explain the structure of benzene. I am truly indebted to my teachers for not having any gender bias, for lifting our spirits and telling us that we must unite to fight for our rights

and march on till the goal is won. Now, when I look at the materialism that has penetrated all walks of life and also at the exam-oriented education of our students, I feel that we must have such dedicated and inspiring teachers in school.

I never had as much fun with science as I had during my school years, thus when the choice of a career course was to be made I knew I wanted to study science.

After much deliberation, I decided to join the integrated physics course at Punjab University in my home town, despite the fact that due to my success in the National Science Talent Search Examination I had offers from the Birla Institute of Science and Technology (BITS), Pilani and the Indian Institute of Technology, Kanpur to join their integrated programmes. This was the first decision in my life prompted by gender. I must admit that having been in a girls' school I was daunted by suddenly having to compete with men.

This was perhaps one of the many acts of cowardice that occurred during my career. It is because of these acts of cowardice triggered by gender issues that I did not fully live up to my true potential as a scientist. Here I was, an honors student, with a rank among the top ten in the country in the science talent exam, and I took the soft option of living at home and going to college, when I could have gone anywhere. Was it my choice? Or was it the fear psychosis engendered in young girls by our society? One thing I do know for sure. If I had been a boy with the same talents, these doubts would not have arisen, and I would have ventured out more confidently into the competitive world of science. Luckily for young girls nowadays, the situation has changed. The elite institutes have become gender-even and the doubts which I had, I hope, are no longer an issue.

My aim was to do mathematical biophysics, but I had not counted upon the pull of the strange and wonderful world of elementary particles. In M.Sc., I had the fortune of having two really inspiring teachers. Dr. Jatinder Bajaj and Prof. M. P. Khanna, who were full of enthusiasm about fundamental particle physics. It was a glamorous and exciting world and I was drawn into it. It had all the mathematical precision and complexity that I instinc-

tively liked. It was abstract as well as natural, so I decided to do a Ph.D in elementary particle physics. What I did not realize was that with my basically fearful but competitive nature, I was entering the most cut-throat and exacting field in the world. It was a jungle out there and I was a small town girl hampered by years of fear-conditioning, ill-equipped for this beautiful but dangerous world of elementary particles and the male domination in the field.

I entered the University of Chicago, with a big chip on my shoulder and a big ambition to do elementary particle physics. I was the only woman in the freshman class. I was surrounded by highly competitive young men, who did not take me seriously at all. I did, however, have the opportunity to work with the renowned physicist, Prof. Yoichiro Nambu. He was very inspirational, albeit formidable, and I learned a lot from him. I could have learned much more had I not been coping with the problems of being a woman in a man's world.

For the first time, I felt that the speculative intuitive type of woman was less likely to succeed than the silent unoriginal type. There was the overwhelming feeling that the flexible all-round intellectual woman was not tough enough to bear the toil of scientific research. My love for physics and keenness to be a physicist were in constant conflict with my need to fit in and have a healthy social life. In the end, in spite of many opportunities to do research in the United States (US), I decided to return to India, because I felt unable to cope with the social pressures of being a woman in physics in the US. It really was difficult to be an acceptable scientist and an acceptable woman at the same time. It is very difficult to gain acceptance to the "boys' club" in physics. If a woman had to do well it is better to be a follower than a discoverer, was the message I got.

In India, I felt while there was not such overt discrimination against women, there was a subtle one. Men were the leaders, but women were quite well-represented. They rose to a certain comfort zone and then did science within that zone. It was conducive to work this way, until one reached a certain stage and found that the competitive urge had died away. Unlike the US where the few women in science supported each other, in India, I found that

women in physics did not unite, but competed against one another. There was and is no “sisterhood” as in the States, perhaps because a woman here vies for acceptability by the male community. It is very difficult to defend women’s competence if the person bringing you down is another woman.

I have recently been influenced by a question asked by biophysicist Evelyn Fox Keller. How far is the nature of science bound up with the masculine ways of thinking which engendered it, and can science be truly universal and objective if it is so conceived? Now, it is my opinion that both gender and science are socially constructed categories. Historically, the stronger conjunction has been that of science and the socially defined masculine attribute of reason, as opposed to the socially constructed feminine attribute of emotion. We have to shift our focus and acknowledge the need for diversity among scientists, the key to which is gender.

Theoretical physics is mathematically neat; it explains the world around us in a fundamental fashion. It would be enriched if more women were prompted to study it. All the gender-biased adversities have made me stronger and even more ambitious to succeed, and I do science without regret or apology. I hope my experience will help young girls faced with the same choices. They should go out there, support one another and seize the day.



12

Full faith in myself

Meenakshi Banerjee

I had my schooling at the Irish Convent, Loreto, in Asansol, West Bengal. Perhaps the earliest memories I have are of myself as a very determined child with a deep appreciation of and inquisitiveness regarding nature although not understanding most of it at that tender age. The most cherished moments of my childhood were those I spent in the big garden I was fortunate to have, gazing at a flower or seeing the insects hovering around it and wondering what was going on. It was probably this fascination and passionate desire to understand that led me to almost decide that I wanted to study on these lines though I did not know exactly where it would lead me. At that age, the scientist in me was already in the making, deep in my mind.

Throughout my school career I enjoyed my studies, games, music, dance, and debates, and won many prizes but the curiosity about nature remained with me. After school I did my intermediate in science from Nirmala College, Ranchi University and then enrolled for my bachelor's degree at Women's College, Banaras Hindu University where I studied Botany. I went on to do my Masters in Botany from the C.A.S. at the same university. I came across cyanobacteria in my special paper and this resulted in my becoming a cyanobacteriologist.

I began with nature in general but ended up studying the tiny but beautiful blue-green microbes! I worked for the Ph.D. with Prof. H.D. Kumar and joined Bhopal (now Barkatullah) University as a lecturer immediately after Ph.D. and have been there since.

My parents' support was a primary factor in facilitating my education right from the start. They encouraged me to pursue a different life probably because they knew I was different although I may not have known it at that time. Unlike other women of my generation, I did not have to choose between family responsibilities and career. My parents never asked me to do anything against my wishes, being aware that my studies and later career constituted happiness for me. I also realize that they made many small and big sacrifices to make my sailing smooth and therefore, for me, the greatest pleasure was not what I achieved but to see the happiness in my parents' eyes at each and every success of mine. My elder brother's selfless support in times of need and his deep affection and appreciation that I have always enjoyed and am still enjoying has been a big additional factor.

As a professional I enjoyed young investigators as my doctoral students, who trained in my laboratory and are scattered throughout the world today. International fellowships and awards, research, extra curricular activities, and music have helped me to convert all disadvantages into opportunities, to learn from them and to grow stronger within. I cannot say that my life has always been smooth sailing, but nobody's is. I have always met challenges with faith in myself. Perhaps my steely determination and confidence in myself right from the start, immense self respect, progressive aggressiveness and honesty in my endeavors, creative outlook and a wish to carve a niche for myself, and above all a deep desire to be different in a good way and stand out in a crowd, have sustained me throughout my career. The constant blessings of the Almighty and of my parents, who are unfortunately no more here to relish my success, give me unforeseen courage at times of need.

I do not know what the future holds for me but I will keep on walking the path that I have chosen for myself because I believe that at the end of the day I should be happy to reflect on a

useful, glorious life well lived. A thought I would like to share with the women who are about to choose a career in science is that nothing in life is to be feared. Everything is only to be understood. If you realize your potentials go ahead fearlessly with full faith and confidence in yourself because I believe, and you should too, that the sky is the limit, but you have to fly to understand the heights you can reach.



13

How I became a biophysicist

Manju Bansal

An important milestone in my journey towards becoming a scientist was my father's decision to give up a cosy lecturer's job in Haryana to accept an uncertain contract appointment to teach English in far-away Hyderabad, where he had to move along with a young wife and three small children. The cosmopolitan atmosphere and increased competition in a large school did wonders for enhancing my interest in studies. Every time I did well in an examination my father rewarded me with gifts of books and thus nurtured my lifelong passion for literature.

I do not remember exactly when I decided to study science or even think of it as a career option but one incident during my high school days does give some indication. The all girls' school where I was studying decided to withdraw the option of offering higher mathematics as an elective subject. At first I did not realize that the number of maths classes had been reduced and we were being taught only basic mathematics. When I became aware of the school's decision, I was very upset and though not keen to study engineering, still insisted that I should be allowed to study higher mathematics and not biology. I was all set to leave the school but surprisingly the principal relented and arranged for a special

maths class exclusively for me and a fellow student who had similar interests. Today, such consideration from the head of a premier school would be unthinkable.

Ironically, though, within a few months I had to shift to a school at Dehradun for personal reasons and I found that due to the earlier events, I was now lagging behind in the maths class. I requested the maths teacher at the new school to give me extra coaching but this exceptional man, after talking to me a couple of times and observing my performance for a month, actually refused and asked me instead to try and solve all the problems in the book myself. I was to approach him only if I got stuck with a really difficult problem. At that time I was hurt and angry, but I later realized what a wonderful piece of advice it was and what a great compliment this unusual teacher had paid me. This helped me score good marks and also inculcated in me an abiding interest in the 'problem solving' approach.

The next major event was my reckless decision to opt for specialization in biophysics for my master's course, instead of the more popular solid state physics or even more glamorous nuclear physics. Biophysics was introduced that very year and, as is usual in Indian universities, without much preparation. We were however lucky to have a couple of enthusiastic teachers and access to some good books. Thus, after having strenuously objected to studying biology at school, I found myself thoroughly enjoying this new found subject, although still uncomfortable with dissecting frogs to study their muscle contraction. What appealed most to me was the strange but happy marriage of biology with physical science!

My admission to the Indian Institute of Science for doctoral work at the Molecular Biophysics Unit thus seems to have been the culmination of a predestined goal. Here too I was fortunate enough to work with stalwarts like Professors G. N. Ramachandran and V. Sasisekharan. These two brilliant scientists with completely divergent personalities taught me the meaning of real research – not just to pursue the comfortable and non-controversial 'me too' science but to question the accepted dogmas even when it leads to uncomfortable situations.

I was also fortunate to get a feel for the importance of basic research in understanding real-life human diseases, while looking for a biological role for the hydroxyproline aminoacids in the protein collagen (for my doctoral work under Prof. Ramachandran). Even more exciting was the post-doctoral research with Prof. Sasisekharan, exploring the possibility of unusual structures for DNA, at a time when it was blasphemous to even think about it! The idea that a structure other than the celebrated Watson-Crick double helix actually exists and plays an important role in the biological function of DNA is now fairly well accepted. It is with no small degree of satisfaction that I look back on the last thirty years and sincerely feel that our work has made some important contributions towards a better understanding of this basic building block of nature.



14

Science is fun every single day

Sudha Bhattacharya

Migrating from a small town in the Punjab, after India's partition in 1947, my mother landed in New Delhi as a young bride. Months of bloody turmoil followed, during which the future appeared grim and uncertain. But after the dust and hatred had settled, my mother began to slowly realize the great potential independent India seemed to offer in the field of education. For one thing she observed these 'Madrasis and Bengalis' around her who were so highly educated- yet led such 'simple' lives- and she secretly resolved that her children must get the best education. So what if that needed money, which was hard to come by? And so it was that my father found himself willingly spending a substantial part of his salary on sending his children to top-of-the-rung 'English-medium' schools rather than the free-of-cost neighborhood school.

In high school, science and maths came naturally to me, and I easily scored high grades. I was a very dreamy girl (still am!). I was not driven by ambition and drifted merrily along. Since I was scoring well (even better than many of the 'Madrasi and Bengali' girls in my class), my mother was satisfied. However, I had no personal goals- no thoughts for my future. My mother, on

the other hand, did have a goal for me. She thought I should do my B.Sc., B.Ed., take up a teaching job and get married. I can't blame her. In a family where most of the boys, not to mention girls, didn't enter college, that was ambition enough. In any case, she had never heard of a Ph.D.

Whether it was the way science was taught in school, or my own dreaminess, or my mother's emphasis on scoring high marks), I more or less looked at science as a subject to score highly in, rather than as a source of wonderment or of creative joy. It was only in class eleven, when we were introduced to genetics, and the DNA double helix, that I felt myself participating in the thrill of scientific discovery, of not merely accepting the formulae laid down in the text book, but of stopping to wonder and question. However, I still never imagined myself becoming a practicing scientist.

My first realization of how timid I was in my approach to life came when we attended our first National Science Talent summer school, where we met the contingent from Mumbai. These students had much better exposure than the Delhi group; they had met internationally renowned scientists visiting Mumbai for lecture tours; they knew about the thrilling discoveries in molecular biology, and it occurred to me that it was within my grasp to explore more challenging avenues than school teaching. At the same time, I realized the blunder I had committed in selecting botany as my subject of study in B.Sc. (Hons.). Since my heart was, by then, firmly set on molecular biology I found it impossible to reduce the beautiful and myriad differentiation processes in plants to mere 'life cycles' to be mugged up.

Relief arrived in the final year of B.Sc., when we got an excellent and charismatic professor to teach us plant physiology. You could sense electrons getting energized by photons of light impinging upon chlorophyll. It was participatory teaching where, apart from being informed of the established facts, we were also made aware of the grey areas, which required further research to get illuminated.

As far as I was concerned, school teaching was definitely fading into the distance. A new ambition to do research in molecular biology was taking root, without my consciously realizing

it. But that meant getting admission into M.Sc. biochemistry. In the whole of New Delhi only two institutes offered that course – the All India Institute of Medical Sciences, and Indian Agricultural Research Institute, and both admitted only one or two students each year in this subject. As luck would have it, that year, 1971, A.I.I.M.S. decided not to admit any student to this course. So that left only I.A.R.I., which had two seats.

My mother refused to let me try for admission to institutes outside Delhi because she was preparing to look for a groom for me. She was already upset with me for vetoing her idea of opting for B. Ed. Not wishing to rock the boat further, I decided to prepare really hard for the I.A.R.I. interview, and as is usually the case, when you really want something you get it. Getting admission into the M. Sc. biochemistry course at I.A.R.I. was the final turning point. Excellent teachers instructed us in state-of-the-art molecular biology, molecular genetics and enzymology.

Meanwhile, pressure was building at home to initiate the process of arranged marriage – for which one had to get photographed in a suitably attractive pose. That was the first time my mother heard of my plans to do a Ph.D. A storm literally broke loose. The same mother who years ago had resolved to give her children the best education now declared that enough was enough! My father could understand my desire for a career, but he was branded as most impractical in these matters. Actively arguing with my mother was not an option. Knowing how much she had sacrificed in the prime of her life to give me the education I could easily have missed, I had no right to break her heart. At the same time, growing up at the peak of the feminist movement I was almost obliged to withstand such pressures. The only path left to me was passive resistance- an otherwise arduous route, but one that becomes easy when you develop the confidence that arises from understanding your innate strength.

So, with a bit of 'Gandhigiri,' I managed to stall my mother's attack and completed my Ph.D. Meanwhile, slowly I tried to convince her that a woman's place in the world was not the same as before, and that marriage was not the ultimate goal of life, with the result that when I, still unmarried, set sail for the U.S.

with a postdoctoral fellowship she was no longer worried about my future. In fact, two years later she herself stepped out of the house to work for a voluntary organization that had set up schools for slum children.

In retrospect, my mother did me a favor by offering resistance. It toughened me and prepared me for further challenges. The most difficult challenge was when I myself became a mother. In whose care could I leave my lovely little daughter and go off to the lab? The absolute and unconditional support of my husband, himself a scientist, and also a collaborator by that time, was a big help. Yet, he had his own immense pressures to bear. We had just moved to a new job, in a new city, and were new parents. We worked in shifts for almost a year until we could find a reliable day care. However tough the going, our research had become such an integral part of our lives that one could hardly imagine life without it. That was my sustaining force.

Earlier on, during my Ph.D., I had realized how lucky I was to get into scientific research. The power, however infinitesimal, of hoping to comprehend how life processes work, was to me a soul-elevating experience. It was exciting that one could lead a whole life in such pursuits. One could have fun every single day- if not with one's own research findings, then with new discoveries coming from other lands. Even the frustrations one experienced almost on a daily basis were part of the fun, because finally when a new experiment worked, it was the purest form of joy.

My personal take on scientific research, after having dabbled with it for that many years, is that if fame and wealth are what you expect from a career in science you are asking for too little. For when science is practiced in its pristine form, it has the power to elevate you to a finer level of existence- one where Truth is absolute and the narrow limits of human perception are duly acknowledged.

So, to the young women choosing a career in science, I would say (borrowing from a popular ad)- When it comes to Science, be demanding... because you are worth it!



15

Geomagnetism gave me my bearings

Archana Bhattacharyya

Among the people that I knew an acceptable career in science, for a woman in the 1960's, would be teaching in a school or college. At least that allowed for long vacations, which coincided with school holidays! However, for a teaching career or even joining the highly coveted Indian Administrative Services (IAS), it was not necessary to study science. Therefore, my wish to move from a girls' school where no science (except 'domestic science') or higher mathematics courses were offered, to another where I would be able to study these subjects, was not encouraged initially. However, my love for mathematics prevailed and I was eventually allowed to change my school.

I was fortunate to take up the study of science at a time when the government of India had just started to offer scholarships in undergraduate and postgraduate studies in basic science. As one of the first batch of all-India 'science talent' scholars, not only did I get a good scholarship throughout my B.Sc. and M.Sc. days at the University of Delhi, but also had the opportunity to attend summer school at the Tata Institute of Fundamental Research (TIFR) and Indian Institute of Science (IISc). This kind of exposure strengthened my feeling that I would enjoy a research

career in theoretical physics. For my Ph.D. at Northwestern University in the United States, I worked on a problem in condensed-matter physics. This gave me the opportunity to experience the joy of traveling into uncharted territory and deciding my own trajectory, which I think is the ultimate reward of a research career in science, and which cannot be measured in terms of monetary benefit alone.

A couple of months after I defended my Ph.D. thesis, my daughter was born, and I decided to take a break, because I felt that I was not capable of doing justice to a post-doctoral position at a good university and handling a small child when my husband, also a physicist, was starting his second post-doctoral assignment prior to entering a difficult job market. A three-year break immediately after my Ph.D. made me open to the idea of taking up research in an interesting area of physics different from my Ph.D. research topic. That is how I discovered the Indian Institute of Geomagnetism (IIG), a small institute tucked away at the southern tip of Mumbai. Its proximity to where my husband worked and where we would live certainly made it a more attractive option and in 1978 I joined IIG as a research associate. I was so thrilled with the idea of getting back to a research career in physics that I did not even find out before joining IIG that a research associate was not equivalent to a post-doctoral position. However, to my great delight, I found that there was much more to geomagnetism than the name suggested. Physical processes occurring deep inside the Earth, in its fluid outer core, as well as events on the Sun leave their signatures on the measured geomagnetic field. The influence of the geomagnetic field on the electrodynamics of the ionized part of Earth's upper atmosphere – ionospheric and magnetospheric plasma – creates a wonderful natural laboratory to study a variety of plasma instabilities.

In the early 1980's, I was asked by the then Director of IIG to initiate a study of 'ionospheric scintillations' using digital data. Although this phenomenon, which involves scattering of incident radio waves by inhomogeneities in the ionosphere caused by plasma instabilities, was being studied in India using analog records, no Indian scientist was working on the theoretical aspects.

With my interest in theoretical problems related to ionospheric scintillations, began my solitary journey into the intricacies of this subject. An opportunity to work at the University of Illinois in Urbana-Champaign during 1986-88 proved to be a turning point in my career, as it brought about international exposure, and on my return to India, I was able to chart out my area of research much more freely than was customary for scientists at my level in IIG those days.

Around this time I found that though geomagnetic secular variation models were being used to obtain fluid flow on top of Earth's fluid outer core, no attempt had been made to extract additional information from secular acceleration of the main geomagnetic field, which became available after regular satellite observations of the geomagnetic field started. Using secular acceleration models, I estimated the radial gradient of the unobserved toroidal part of the main geomagnetic field at the core-mantle boundary, an important component of the geodynamo. This gives an idea of the broad range of problems that the area of geomagnetism has to offer.

My study of plasma instabilities in the equatorial ionosphere, which have particular relevance in our region from the point of view of their impact on space-based communication/navigation systems, such as the Global Positioning System (GPS) and which form an important component of 'space weather', continues. Transient events on the Sun such as coronal mass ejections, under certain conditions, affect earth's magnetosphere giving rise to magnetic storms and sub-storms, and to changes in the ionosphere. A major goal of a number of international programmes today is to make predictions of 'space weather'. 'Climate and Weather of the Sun-Earth System' (CAWSES) is one such programme, with which I am involved.

As Director of IIG since early 2005, I now have to devote considerable time to science administration, a redeeming feature of which is that I have been able to broaden the scope of research at IIG. If I had to do it all over again, I would definitely be more proactive in planning my career. I am happy to see that young women today have more well-defined goals.



16

The enthusiasm of a novice

Rajani A Bhisey

I was fortunate to have been born to parents who actively participated in the struggle for India's independence and were also academically oriented. A few years after release from rigorous imprisonment, my father became interested in the synthesis of textile dyes that until then were imported. In our home there was a chemistry table at which my father used to work. He let his kid smell harmless organic chemicals, and amused her by showing change in the colour of phenolphthalein after it was added to an alkali. This was my first fun-filled acquaintance with science. At school, what I really liked was languages, and algebra. After passing the high school examination with distinction, an aptitude test suggested by my father resulted in my opting for science. Reading '*Microbe Hunters*' a book from his collection led me to opt for Microbiology for B.Sc. degree. In 1960, when I passed B.Sc. examination, the university of Bombay did not offer M.Sc. courses in microbiology, therefore I had to think of obtaining M.Sc. degree by research.

The knowledge of electron microscopy obtained due to my fascination with the world of tissue cultures described by a senior doing M.Sc. at the Cancer Research Centre, helped me gain admission for research there, which was to become my vague

throughout my life. The institute provided highly charged academic environment and also the joy of mastering unknown techniques. But there was time for recreational activities as well. Raju Bhisey, a young, bright research Ph.D. fellow was my badminton partner. He won my heart but not many badminton matches.

My master's work lingered on, in fact there was nothing we could do at the Ultrastructure department for a couple of years, as the 1962 war with China had impoverished the country and there was no foreign exchange available for purchasing chemicals and simple accessories like grids, required for doing electron microscopy. After obtaining M.Sc. degree in 1965, I was recruited as a Scientific Assistant at the Cancer Research Institute. The job provided a little more money and I was also allowed to register for Ph.D. degree. Around that time, my husband obtained the position of a postdoctoral associate at the Institute for Cancer Research at Fox Chase Philadelphia, USA. Naturally, our son and I accompanied him to USA. This resulted in a break in pursuing my doctoral work. But I used the opportunity to gain expertise in different aspects of electron microscopy. In the laboratory of late Dr. Jerome J. Freed at Fox Chase Cancer Center, I looked at the cell surface of cultured cells by doing histochemistry at ultrastructural level. Regrettably, nearly 2 years of hard work failed to produce any significant results.

After returning to India, I worked hard and obtained Ph.D. degree under the guidance of Dr. Mrs. S. M. Sirsat, a pioneer in electron microscopy. Soon came the time for developing my own area of research. My intention was to explore the mechanisms involved in skin tumor promotion, and environmental carcinogenesis in the hope of understanding how some benign lesions develop and progress to cancer in humans. I soon realized that animal models needed to be developed for determining whether certain products of common usage suspected to cause cancer in humans are carcinogenic in animals. I concentrated on the development and characterization of a mouse model that would be sensitive to skin carcinogenesis. Several years later with the help of my colleagues we could use these mouse strains to demonstrate carcinogenic potential of chewing products such as *paan* masala and gutkha.

Yet another opportunity to diversify came along when Dr. M. G. Deo, then Director CRI, gave me the responsibility of setting up a genotoxicity laboratory. The idea was to develop expertise in monitoring genotoxic hazards among the people exposed to hazardous chemicals. Technical expertise had to be acquired in assessment of human exposure to chemicals, cytogenetics, and genotoxicity assays. Simultaneously, I had to identify a target population that was highly exposed to genotoxic agents. I decided to study the health and genetic hazards caused by occupational exposure to tobacco among workers who are exposed to exceptionally high levels of tobacco dust and volatile components.

With the enthusiasm of a novice, I took the short route to the Indian Tobacco Company for monitoring workers in their cigarette factory. My visit was totally unsuccessful. I was back to square one. We found that maximum amount of tobacco dust was inhaled by the tobacco processors, the majority being women. Having identified the worker population in Nipani in Karnataka, I tested our logistics with a field study, with a base camp in Shivaji University, Kolhapur. It was obvious that maximum amount of tobacco dust was inhaled by the tobacco processors, the majority being women. Having identified the worker population, and chalk-ing out a programme, the question was where could we conduct our laboratory work? Upon my request, the vice chancellor of Shivaji University kindly allowed us to set up a temporary laboratory at the Department of Biochemistry, Shivaji University, Kolhapur. The field study tested our logistics, and patience, yet it provided much satisfaction from the interaction we had with the workers. Our efforts in two tobacco factories lasting more than a decade indicated that *bidi* industry workers incur considerable genetic damage and are at high risk for development of respiratory diseases and cancer. In this case, social contacts and concerns I had, helped me identify the worker population.

Simultaneously, experimental work using animal, cell culture and human material provided clear evidence that tobacco addicts absorb tobacco mutagens and experience oxidative damage to macromolecules. However, the reality is that among millions of heavy tobacco addicts, only some develop cancer. My work

on genetic polymorphism in tobacco metabolizing enzymes led us to demonstrate that heavy chronic tobacco users who lack the GSTM1 gene that encodes the carcinogen detoxifying GST mu enzyme are at high risk for oral cancer when compared to those who have the allele. Once again my students made me proud when this data was selected by the International Agency for Cancer Lyon, France as one of the very few large and conclusive studies for meta-analysis of the link between this gene and head and neck cancer risk.

My husband and I worked in different areas of cancer but debated and discussed scientific issues. The atmosphere was academic at our home. Our children too imbibed our love for knowledge. I had wonderful colleagues and the Cancer Research Institute provided valuable infrastructural strength. I owe a lot to my students, from each one of them I learnt something valuable, our group discussions brought forth new ideas and questions. I must confess my tremendous gratitude towards my less fortunate sisters, bidi rollers and particularly tobacco processors with whom I could share home made *Bhakri* and vegetable in terribly dusty atmosphere which they patiently suffered. Without their support and that from innumerable people, human studies we made would not have been possible.



17

The excitement of colours and scents

Renee M Borges

“Out of a swarm of bees, one-fifth went to a *kadamba*-flower, one third to a plantain-flower, and three times the difference of those, O doe-eyed one, to a *kutaja*-flower. One remaining bee, tempted at the same time by the scent of a jasmine and a pandanus, hovered and wandered in the air; tell me, beloved, the number of bees.” From *The Lilavati* of Bhaskaracharya

From Bhaskara’s data, the *kutaja*-flower appears to be the most attractive (six bees out of fifteen go to this flower). Bhaskara’s problem also implies that the sensory modality being used by the bees to approach the flowers is floral scent, although this is made explicit only in the case of the one confused bee that “hovered and wandered in the air” tempted simultaneously by two equally attractive floral perfumes. This could have been a description of an olfactometer experiment on a population of wasps, ants or bees being conducted in my laboratory, except that we would know the number of test organisms in advance and the unknown quantity that Lilavati would have to determine here would be the preference of the insects for the scent of the different simultaneously available flowers. My current work on the chemical communication between plants and animals would offer Bhaskara many contexts for the composition of complicated mathematical problems.

I am a strong believer in instinct. It was instinct that made me realise when I was very young that the only subject that could hold my attention was the natural world. Having been born into a family where medicine was an important vocation, this fascination with the natural world translated into an early desire to become a veterinarian (around the age of seven). My indulgent family responded to my request for a dog, and my dog and I grew up together, providing me with insights into animal behaviour that have helped me in my professional career.

Intellectually, I believe my greatest development took place in the first two years at Saint Xavier's College, Mumbai. I joined a Creativity Group formed by the ever-enthusiastic Jehangir Mistry, a teacher in the Physics Department. Our small group of sixteen students, drawn from diverse disciplines and interests, bonded immediately, and collaborated on science projects that culminated in an exhibition. The atmosphere of freedom, excitement and joy in the learning process that I experienced here is something I have attempted to retain all my life. I consequently decided to do a Bachelor's degree in zoology and microbiology in the same college.

Another important event in my development was joining the Bombay Natural History Society (BNHS), which was a haven for the serious amateur naturalist and the committed professional. During my BSc, I spent evenings working with Humayun Abdulali at the BNHS, on the bird collections of the Andaman and Nicobar Islands. This gentleman-naturalist frightened off people with his penetrating questions and caustic humour, but he and I got on famously, and I learnt much about scientific rigour from this seventy year-old man. I got to know Abdulali's cousin, Sálím Ali, at whose suggestion and under whose supervision, I wrote a series of popular articles on ecology and evolution while pursuing an MSc in Animal Physiology at the Institute of Science in Mumbai. I admired Sálím Ali for his wit, passion, and uncompromising striving for perfection. Nothing was ever good enough for him.

By this time, I "knew" that I wanted to make a career in ecology and evolution. I also realised that I could not do this in India. I decided to join the University of Miami, Coral Gables,

Florida, where I received a Maytag PhD Fellowship and the opportunity to work in their extremely successful Tropical Biology Programme. The Miami experience taught me scientific independence because graduate students had to write their own grant proposals and obtain their own research funds. This was especially true for me, because my PhD supervisor, Ted Fleming, worked on bat–plant interactions, and I was not inclined to study bats. However, Ted gave me free rein, and with my now, more focussed interest in plant–animal interactions, I developed a proposal to study the relationship between phytochemistry and food choices in the herbivorous Indian giant squirrel *Ratufa indica*. But I still had to get the money to do this research. At this point, I approached the Office of International Affairs of the United States Fish and Wildlife Service. I must record my gratitude to David Ferguson who not only supported my Ph.D. research through this office but later also my post-doctoral work. With this support, I was able to spend two years in India, a year each in Magod, North Kanara, Karnataka, and in Bhimashankar, Maharashtra, collecting data for my degree. These years were perhaps the most formative in my personal development, because I lived alone in these forests, drove my own jeep through the forests, hired my own local field assistants, and made enduring friendships, both personal and scientific. Since giant squirrels are found only in dense forests, in remote areas, these two years also gave me, an urban product, my first contact with true rural India. Back in Miami to write up the thesis, I found the international atmosphere most invigorating. My fellow students were working in or were from geographical areas as diverse as Papua, Peru, Venezuela, Costa Rica, Ghana and Europe, and I happily adopted global intellectual citizenship.

Returning from Miami with my Ph.D., I continued to work on giant squirrels with a five-year post-doctoral support grant routed through the Wildlife Institute of India (WII) in Dehradun where Hemendra Singh Panwar, one of India's most renowned Indian Forest Service (IFS) officers, was the Director. He very kindly gave me adjunct status in the Institute. During this same period I joined the Bombay Natural History Society as Deputy Director (Research) and encountered Hema Somanathan and Subhash Mali,

my first two Ph.D. students who worked both on giant squirrels and on plant–pollinator interactions within the seasonal cloud forests of Bhimashankar, under the aegis of this cross-institutional collaboration.

By this time, the Centre for Ecological Sciences (CES), Indian Institute of Science (IISc), advertised faculty positions, and I was fortunate to be accepted. Here, I believe I have found my bearings, and indeed everything that I could possibly have wished for in terms of scientific atmosphere, and most importantly, academic freedom. I will never forget the first meeting I had with Raghavendra Gadagkar after I joined CES. Gadagkar was Chairman of the Department, and when I, perhaps a little self-consciously, went to meet him in his office, I was most pleasantly surprised when we discussed academic freedom instead of duties and responsibilities. This is what I enjoy the most about IISc, and what I believe any wonderful institution such as IISc, should foster and celebrate.

Here at CES, I have been able to develop a lab that is dedicated to asking questions on the interactions between species within the framework of evolutionary biology. I have wonderful colleagues, students, research associates, and research assistants, and every day brings new excitement, scientific friendships and collaborations. Together we have found the world's first truly nocturnal bee that can pollinate plants and see colour in starlight; we have studied arboreal earthworms that live within ant-plants; we have found out that ants can learn the odour of wasps that they prey upon; we have discovered that male ant-mimicking spiders can find out whether a silken nest belongs to a virgin female just by chemical cues of the silk; we have discovered how crab spiders can be successful at mimicking flowers; we have found that plants produce scents to attract appropriate visitors and also scents to repel inappropriate ones, which may explain Bhaskara's observations to Lilavati on the visitation patterns of bees.



18

A woman scientist in a field dominated by men

Bimla Buti

Looking back at the time when I decided to take up physics as my profession, I find it rather hard to figure out what prompted me to do so, since no one in my family, until then, had studied the pure sciences.

Having migrated to Delhi from Lahore at the time of the partition of India, I got admission in a government school which did not offer science as an option. Consequently, I was an arts student in High School. However, mathematics was my favourite subject. My father was a gold medalist in (M.A.) mathematics from Punjab University, although he became a lawyer. Since I had done the matriculation examination, not the Higher Secondary, I had to take a one-year course at Delhi University before I could get admission into B.Sc. (Hons.). At this stage I opted for the physics, chemistry, mathematics combination rather than biology for the simple reason that I was scared of cutting open frogs, maybe because I am a vegetarian. My sister's husband, a medical doctor, tried hard to persuade me to study medicine, but my father encouraged me to pursue the career of my choice. I did not enjoy chemistry but did like physics, probably because of my interest in applied mathematics. I considered going into engineering but for

that I would have had to go out of Delhi. Neither my family nor I liked this idea. This, probably, was the reason I chose Physics (Hons.) at Delhi University.

After B.Sc. (Hons.) and M.Sc. Physics from Delhi University, for my Ph.D. I went to the University of Chicago, where I was privileged to work with Nobel Laureate Prof. S. Chandrasekhar. Besides my father who molded me during my early years, it was my Guru Chandra (Prof. Chandrasekhar was addressed as Chandra by his students, colleagues and friends) whose training had an indelible effect on my professional life later on. The virtues instilled in me in childhood, like self-reliance, the confidence to face all kinds of situations and the courage not to bow to unjust pressure, were strengthened by my association with Chandra. I always spoke my mind fearlessly, and most of my seniors did not like this. I suffered professionally both because of this and because of gender bias. But I have no regrets.

For the sake of my profession, right from the beginning, I had decided not to marry. I took this decision because of my habit of doing full justice to my work, and tirelessly pursuing every task I took on. Marriage would have meant not doing full justice either to my family or to my profession. Being single, I was free to focus on my professional commitments.

Prof. Chandrasekhar had worked in many diverse fields. He would work in one field and after doing a thorough job in it, he would write a book and then move on to a different field. At the time I joined him, his field of interest was magneto-hydrodynamics and plasma physics. I had specialized in plasma physics. For my thesis, I worked on relativistic plasmas. My way of working has been to first develop a general model and then apply it to problems of my interest in space, astrophysical as well as laboratory plasmas. Using the techniques of nonlinear dynamics, I interpreted many observed phenomena in terms of nonlinear, turbulent and chaotic plasma processes.

After my Ph.D. from Chicago, I returned to India and taught at my Alma Mater, Delhi University, for two years. I then decided to go back to the US to work as a Resident Research Associate of the National Academy of Sciences, at the Goddard Space

Flight Center, NASA. There I was associated with the Theoretical Division headed by a brilliant plasma physicist T. G. Northrop. Life there was very different from my student life at Chicago but my tenure (over two years) was very fruitful and enjoyable.

I next worked at the Department of Physics, Indian Institute of Technology (IIT), Delhi, as a Senior Scientific Officer. It is during this period that Chandra was invited by then Prime Minister Indira Gandhi to deliver the Nehru Memorial Lecture. After the lecture, Mrs. Gandhi organized a banquet in Chandra's honour and as a Chandra's student, I was also invited to this dinner party. I was a small fry at this gathering that included dignitaries like Vikram Sarabhai, D.S. Kothari and the President of Indian National Science Academy (INSA). I met Prof. Sarabhai for the first time. Right then and there, he invited me to work at the Physical Research Laboratory (PRL) of which he was Director. This is how I joined PRL and spent twenty-three years of my professional life as Associate Professor, Professor, Senior Professor and Dean of Faculty there. The research atmosphere at PRL was quite different from that at IIT and Delhi University. Sarabhai did not believe in vertical hierarchy, and he gave full freedom and responsibilities to the scientists. We managed to establish a very strong group in plasma physics, both theoretical and experimental, at PRL. I initiated and founded the Plasma Science Society of India whose registered office is still at PRL. I am really proud that all my students, who are settled in India and in America, are doing very well professionally and otherwise.

While at PRL, I had opportunities to visit and work at other NASA centers, like the Ames Research Center and the Jet Propulsion Laboratory (JPL), California, for longer durations. Besides visiting NASA Centers, I worked at the University of California, Los Angeles, from 1986 to 1987. In the capacity of Director of Plasma Physics at the International Centre for Theoretical Physics (ICTP), Trieste, Italy, from 1985 to 2003, I had many opportunities to interact with a large number of scientists from many developing and developed countries. I had to spend quite a bit of time organizing Plasma Physics Colleges at ICTP every alternate year for participants from developing countries, but I think

it was worth it since the colleges gave participants an opportunity to come into contact with a number of leading plasma physicists who came to lecture at these colleges.

I was fortunate enough to be elected an INSA Fellow, the National Academy of Sciences (NAS), the American Physical Society (APS) and The Academy of Sciences of the Developing World (TWAS) in 1990 when TWAS had only a handful of Indian Fellows. I was the first Indian woman Fellow of TWAS and the first Indian woman Physicist Fellow of INSA. I have used the word 'fortunate' for the simple reason that one has to be nominated for any worthwhile award and for the Fellowship of the Science Academy, and it was almost impossible for me, a woman scientist in a man-dominated field, to get nominated for prestigious awards like the Bhatnagar award. Another incident of differential gender treatment was apparent when the Director of PRL was to be chosen in the mid-1980s. Invariably, I had to face the jealousy of my male colleagues.

It may sound strange but it is true that one's scientific work is appreciated much more abroad than it is in one's own country. In spite of gender differential treatment from the scientific community in India, I got the Vikram Sarabhai Award for Planetary Sciences, 1977, the Jawaharlal Nehru Birth Centenary Lectureship award, 1993, the Vainu Bappu International Award in Astrophysics, 1994, and the Lifetime Achievement award of the University of Chicago in 1996.

After my official retirement from PRL, I again spent four years at the Jet Propulsion Laboratory (NASA), California Institute of Technology. Now I am settled in Delhi, continuing my research and also doing some social work through the Buti Foundation (www.butifoundation.org), which I founded in 2003. To my great satisfaction, the Foundation is progressing very well.



19

Science – a joyous playing field

Anju Chadha

What was called my stubbornness in childhood finally paid off as persistence when it came to dealing with research problems later in life. Born in Ahmednagar, Maharashtra, I studied in half a dozen schools around the country. In high school it seemed natural for me to opt for science, probably due to the influence of my father, who is a scientist and my mother's belief in my choices. His constant and systematic style of questioning practically everything around him influenced me profoundly. I studied chemistry at the undergraduate level, and my self-confidence reached a new high when I was ranked among the top five in the final state-level examination.

I went on to complete my post-graduation in organic chemistry from the University of Pune. Exposure to research activity and teaching at the chemistry department of the University fascinated me. I was excited by the clarity with which stereochemistry (three-dimensional structure) was taught, and it took me a while to imagine and build the three-dimensional structures, but what I learned then stayed with me. The problems posed during classes and the imaginative questions that were asked in the examinations made this topic really enjoyable. It was a true case of

having fun while learning. I saw the total involvement of research scholars with their work in the laboratories, and was in awe of their depth of knowledge. I particularly liked going to the library and pouring over Beilstein and Chemical Abstracts. Subsequently I began to understand the questions in organic chemistry which they were trying to answer. I shared my hostel room with a Ph.D. student of philosophy who taught me a lot of stuff other than chemistry through various discussions. I value the time I spent with her, most importantly our friendship has lasted till today.

The magnificence of nature's designs (including colours) in the smallest of living organisms; the magical organization of a living cell and the enchanting diversity of living things always attracted me. The complexity of molecules which comes from simple elements that almost miraculously all come together to constitute life never ceases to amaze me.

I went on to do my Ph.D. in organic chemistry at the Indian Institute of Science, (IISc), Bangalore. Combining my interests in the fields of chemistry and biology, I chose to deal with problems at the interface of these two subjects. For my Ph.D. I worked on xenobiotic metabolism. The molecules we investigated were the constituents of spices and flavouring agents in food. Simply put, my work examined xenobiotic molecules and what happens to them because of enzymes; and enzymes and what happens to them because of these molecules.' This thesis gave me the opportunity to deal with interdisciplinary problems – I used facilities in almost all the departments!

At an international conference on Redox Systems, held in IISc, Bangalore, I presented my Ph.D. work. It was my first such presentation and the appreciative comments made by some well-known scientists in the field made me feel good about my work, but the moment my Ph.D. supervisor congratulated me and said he was proud of me, I was truly happy. I knew he had forgiven me for my 'stubborn' behaviour: following my own style and doing my work according to my own timetable.

My time at IISc, Bangalore was full of a variety of rich experiences which shaped my career and life. Most importantly too, at a deeply personal level, I met my husband and lifetime

companion there.

For my post-doctoral work, fortunately, I had an opportunity to spend some time in the Bioorganic Laboratory as a post-doctoral at the National Institutes of Health (NIH), Bethesda, USA. We studied polycyclic aromatic hydrocarbons, pollutants that are present in smoke. On metabolism these can get converted into cancer-causing molecules as shown by *in vitro* tests conducted in the lab. However, in the body, all these molecules are not found to be carcinogenic. There is a need to establish a direct correlation between chemical structure and the incidence of cancer, for polycyclic aromatic hydrocarbons: the challenge was to find a pattern in the stereochemistry of the metabolites formed and correlate them to chemical carcinogenesis.

At the end of my post-doctoral training I was convinced that natural enzymes are the most efficient catalysts. These amazing protein molecules catalyse thousands of reactions in biosystems, while maintaining their specificity in structure and function. They need special care while handling because they are sensitive to harsh conditions; It has become fashionable for people to refer to enzymes as ‘Green Catalysts’.

I understood the need for such catalysts in the chemical industry and on getting an opportunity, I set up a Bioorganic Laboratory for a pharmaceutical company as part of my first job. I continued to do research in the R&D department, and if it was not considered proprietary information by the management, I insisted on publishing my findings.

While working with the pharmaceutical industry I went to Germany on a Humboldt Fellowship. This experience helped me formulate my ideas on the use of enzymes in organic synthesis. Visits to industrial plants in Europe, which use enzymes on an industrial scale, helped me realize the potential of these wonderful biomolecules.

After some fruitful years in the industry which gave me an insight into the real world of research, manufacturing and business, I joined the Indian Institute of Technology, Madras (IITM). This position gave me the opportunity to utilize academic freedom to pursue research in the area of biocatalysis – exploring the

world for new biocatalysts for known organic reactions and known biocatalysts for new reactions. The IITM also provides a very good environment for teaching young smart kids – some of whom are fresh out of school and are starry-eyed about the world that is waiting for them and others who join for higher degrees and research.

All this adds up to trying to offer ‘green’ or environmentally benign synthetic methods to manufacturers. As a scientist I feel privileged both to understand the science of biocatalysis and to gain the satisfaction of knowing that this work is linked quite directly to societal issues i.e. the environment.

My parents always respected my desire to be independent, and as a child I never felt that I was treated very differently from my three brothers. My early childhood memories are of being encouraged to be fearless and do things alone if others were not willing to join in. As I grew older, I realized the value of this training as I began to understand the problems of other women in our society and the factors which kept them from pursuing their dreams of a serious career.

The relentless pursuit of serious work is not easy for women in a patriarchal society. I am deeply grateful to my family and friends who have at various times helped me discover my inner strengths that allowed me to carry on and never say die. Being married to a scientist helps, as we both understand the nature of our work and our involvement in it.

I encourage young people, especially young girls, to take up research in science as a professional activity and work together with other researchers to build strong centers of science. For women this is the real challenge of equality. I am also committed to supporting the entry and participation of young women in public life as citizens.

I have enjoyed every moment of my life in science and look forward to many more years relentlessly exploring the unique excitement of innovative work. I am happy that as a scientist I have the opportunity to appreciate the ability of human beings to uncover the deeper mysteries of the physical world and am humbled at the realization that the best is yet to come.



20

Negotiating choices

Charusita Chakravarty

As a child in an academic family, I always had a lot of books around and read extensively and fairly indiscriminately. As I grew older, some of this curiosity was channelised towards science, encouraged to some extent by a very good science teacher in primary school and our neighbours who were botanists. Overall, though, when I look back, I can see that the dominant influence in shaping my academic interests was that of my father. I do not remember that he ever paid any attention to homework or examination preparation but he had an enormous range of intellectual interests himself and, when he found the time, he was always interested and encouraging about whatever I might be reading or learning.

The school system and the competitive aspects of studying science began to be important sometime around the age of 13 or 14 i.e. during the Junior and National Science Talent examinations. My school expected every student who was academically good would study science and try to get into medicine. While I enjoyed history and literature, I fell in with expectations as far as science was concerned but I just could not see myself as a doctor.

I wanted to continue with science, and specialize in chemistry. Since chemistry generally gets pretty poor press among the young, largely because of the way it is taught, I feel I ought to

explain my choice. Like everyone with any intellectual ambitions, I liked mathematics and physics and wanted to develop the associated conceptual and quantitative skills. Biology, and in particular molecular biology, was clearly very much the subject of the future. Since chemistry involved the application of physical concepts to understand a diverse range of chemical phenomena, including those in biological systems, I thought it represented a reasonable compromise. Even in the 1980's, B.Sc. (Chemistry) was a fairly odd first choice for anyone to make. To maintain some credibility in the eyes of my peers, I decided I would sit for the IIT-JEE exam and try for the integrated M.Sc. program in Chemistry in IIT-Kanpur. I did obtain a respectable rank in the JEE exam but for various personal reasons the IIT-Kanpur option did not work out.

I ended up in the B.Sc. Chemistry program in St. Stephen's. I cannot claim that I enjoyed it greatly but it left me with a lot of time for myself which I utilized to learn some things on my own. After completing the B.Sc. degree at Delhi University, I went on to do the last two years of the Natural Sciences Tripos in Cambridge, UK. By the time I went to Cambridge, it was reasonably clear to me that I wanted to do theoretical chemistry/chemical physics, not molecular biology, and I chose my options accordingly. I enjoyed the undergraduate experience in Cambridge very much. The effectiveness of being taught by individuals who were actively engaged in their subject made quite an impression on me—not just in theoretical and physical chemistry which in any case interested me, but also in subjects that I did not have to study or have not had to teach since then, such as synthetic organic chemistry.

I chose to stay on in Cambridge for a Ph.D. in quantum scattering and spectroscopy with David Clary. Quantum scattering techniques are useful for understanding reactions of molecules in the gas-phase, specially in conjunction with experimental molecular beam and spectroscopic studies. By the time I completed my Ph.D. in 1990, I knew I wanted to do more work on reactions in condensed phases e.g. in solution and on solid surfaces and this would require learning statistical mechanics and computer simulation techniques. I found a postdoctoral position which would

allow me to make this shift with Horia Metiu in Santa Barbara, California. I stayed in Santa Barbara for just about a year and a half before returning to IIT-Delhi for a temporary position in 1992. In 1993, I returned to an independent postdoctoral position in Cambridge, UK. In 1994, I joined the Department of Chemistry at IIT-Delhi as a faculty member and I have been there ever since. In terms of milestones in my personal life, I got married in 1992 and my daughter was born in 2000.

Given the nature of this volume, it is tempting to indulge in some generalizations based on my experience of being a women scientist in India. The postdoctoral years between 1992 and 1994, when I had no thesis and no postdoctoral advisor to worry about seem, in retrospect, to have been a very formative period when I had academic independence without day-to-day academic responsibilities. In contrast, being a faculty member at IIT required a complicated balancing act between research, teaching and one's personal life.

While the IITs are probably among the few institutions in India where one can combine research and teaching, unfortunately these two activities are not always viewed as mutually complementary. I have found that one of the positive spin-offs of having to teach at both undergraduate and postgraduate levels has been that I have had to keep in contact with the mainstream of the subject and, over the years, this has given me a much broader understanding of the chemical sciences. I have had to adapt my research interests to find problems that are reasonably interesting to me, potentially interesting for my research students and doable within the constraints of the academic environment that I find myself. This has often meant that some attractive research directions could not be pursued or had to be abandoned. Like many others working in India, I have often felt that one's published work tends to be ignored or under-cited. On the other hand, the absence of a high-pressure, grant-driven research environment, typical of the US, has meant that I have had considerable freedom to work on problems of my choice.

The complexities of negotiating gender and professional roles tend to become most acute for most women in their late

twenties and thirties. This is partly because these are the years when decisions regarding marriage and children are made but also because these are the years when one has to establish one's academic independence and viability. In my case, these years also coincided with my decision to return to India. I was born in the US and therefore I had to make a conscious decision to give up US citizenship in favour of Indian citizenship in my mid-twenties. Perhaps for this reason, in my mind, I have found myself comparing the nature of intellectual marginalization due to gender with that due to working in a developing country. Clearly both factors can distance you considerably from the mainstream of scientific activity and can lead to considerable scepticism as to the worth of one's contributions, both in one's own mind as well as that of one's professional peer group. This type of intellectual marginalisation is specially insidious given the nature of scientific research, which requires that any contribution in order to be consequential must be validated and amplified by the scientific community. The glass ceiling that hits one is not just in terms of access and advancement in the organisational power structures of science, but in one's own ability to extend and develop ideas. I raise this issue in the hope that it may help us think of the mechanisms to build up a culture of intellectual self-confidence and productivity, which must necessarily be more subtle than administrative measures to ensure that scientific institutions and activities are more inclusive of different social categories. At personal level, being an "Indian" and a "woman" are as intrinsic parts of my identity as my interest in doing science and therefore, I guess, like most of Lilavati's daughters, I have tried to integrate and do some justice to these different aspects of my identity. In the context of our society, to have had the opportunity to do is to have been quite fortunate.



21

Why and how I became a scientist

Maharani Chakravorty

I was born in 1937 at Bhagalpur, Bihar. During my childhood days I was greatly influenced by my scholarly maternal grandfather. His narration of scientific discoveries always fascinated me. In school, mathematics and science were my favourite subjects and it was my teachers who were responsible for inculcating such liking in me. I passed the matriculation examination in 1950. Coming from a middle class educated background it was taken for granted that I would study further – just the I.Sc. the next two years at the Presidency College, Kolkata.

I can compare my life with the ocean; waves come and go. After my M.Sc, Prof. S.M. Sircar, one of my teachers urged me to join the Bose Institute to work with Dr S. K. Roy. Thanks to the active atmosphere at the Bose Institute and the special care and attention I received from my seniors. I felt a real urge to do good science.

My quest entered an exponential phase when Dr. Debi Prosad Burma joined the Institute. He was a good enzyme chemist and I found him extremely active, pleasant and affectionate. Enzyme chemistry seemed to have a lot of excitement! I learnt biochemistry from Dr. Burma who was the best teacher I ever

had. He used to say that 'It is the teacher who ignites one's interest and love for a subject and then one should sustain it'. But the most important factor is one's inner desire and strong will, without which one cannot gain success. I worked on microbial protein synthesis under his guidance, and this constituted a part of my thesis. Even in those days when knowledge about the mechanism of protein synthesis was quite obscure, we could demonstrate cell-free protein synthesis with a particulate preparation from *Azotobacter vinelandii*.

I was very sure that I could not give up the joy of doing science and realised that Dr. Burma who had keen interest in my scientific career, would be the best person to keep this spirit alive. We decided to go abroad after the submission of my thesis and get married.

I had my postdoctoral training in enzyme chemistry in the laboratory of B.L. Horecker at the New York University School of Medicine. At that time, my husband was working with Severo Ochoa in the biochemistry department of the same school. My first child was born during my stay in New York. A week later I was back in the laboratory. At this stage many young women in the field of science find it difficult to continue with their work. It was very difficult for an ambitious mother to take care of a child and work on enzymes at the same time! I could not leave my laboratory and the work entrusted to me, so our son stayed with a family for five days a week and we brought him home only for the weekends. It was the enthusiasm and encouragement from my husband that helped me a lot.

After I returned from USA and joined the Bose Institute as CSIR pool officer, my children were never in the way! I used to carry my son to the institute with a big piece of rubber cloth and a few bottles of milk. The poor child used to sit on the rubber cloth spread on the floor of the laboratory playing with the test tube stands in front of my working bench. Thank God! Those days the atmosphere in the Bose institute was quite informal. My child got used to that type of life and thus became a laboratory child! In 1965, I transferred my pool officership from the Bose Institute, Kolkata, to the Department of Biochemistry, Banaras

Hindu University, as my husband had joined the department as Professor and Head, a few months earlier. I was happy getting a working place although it was at one end of the teaching laboratory.

In 1967, I had training in ICRO (International Cell Research Organisation) and UNESCO sponsored DNA-RNA hybridisation course from Prof. S. Spiegelman, the father of the technique, at Naples, Italy. I was then a pool officer under CSIR. I did not want to miss this opportunity of training myself which I knew would help me a great deal in my scientific endeavour although I was pregnant at that time and pregnancy was at an advanced stage. Ignorance is bliss. I never knew that one needs a doctor's certificate while travelling at such an advanced stage of pregnancy. My strong will and love for science has helped me to reach my goal even under adverse circumstances.

My second son was born. This time also I worked till the last day and rejoined the laboratory after 10 days. Even then during 15 minutes incubation period of my assay system I used to literally run through the *ayurveda* garden with my lab-coat on and stopwatch in my pocket to check how the child and the babysitter were doing. It was possible only because our house was very close to the laboratory and we lived on campus. When I needed to go to Bangalore to teach a course on 'Bacterial genetics and viruses' leaving my eight month old baby with my mother-in-law at Kolkata, my husband took care of the elder one at home.

Due to want of a liquid scintillation counter I could not carry out some of the experiments I needed to, so I planned to go abroad. Leaving my children behind, I went to Ann Arbor for a year. If you are upright and vocal you face many problems in a male dominated academic world. You don't get a job easily. Initially I did not care much for a permanent position in the university and was rather very happy so long I got a working place. Later, I realised that without a permanent position I would not be able to continue my research. I was appointed as a Reader in the Department of Biochemistry in the Institute of Medical Sciences of Banaras Hindu University and served the university till 1997. During this time, my husband and I, together built the Molecular

Biology Unit with a lot of pleasure (and some pain). After superannuation, I returned to Kolkata. My lust for science continues. I still enjoy doing experiments, with my own hands and I am happy.

Now if I am asked, why I became a scientist, my answer will be, it was my strong inner will and my husband's desire who wanted me to do better. I do science since I love it.

There is a saying, 'There is a woman behind every successful man'. I feel the reverse is also true. 'There is a man behind every successful woman!'.



22

Waiting for sparks

Prabha Chatterji

When I was in tenth standard, our chemistry classes used to be held in the laboratory itself. Our chemistry teacher would write equations on the blackboard proceed to demonstrate those experiments right away. Also very often, she would cite examples from daily life. I clearly remember our visits to the nearby soap factory and the rubber factory. My elder sister and I shared this excitement in chemistry and we often messed up the kitchen and dining table with our “experiments”. All this must have contributed to an increased interest in Science and consequently that showed up brilliantly in the results and naturally guided me towards mathematics, physics and chemistry in the pre-degree (what was the Plus two those days). A turn of events forced us to relocate from the big city to our ancestral village (we “children” were not a part of the decision-making process.) What can a college in a village offer? My sister and I were utterly disappointed and resigned to the fact that this would be the end of our foray into science.

But surprisingly this was not to be. This undergraduate college, hardly two years into existence in a nondescript village near Ottappalam, in Kerala, turned us forever towards science in general and chemistry in particular. To be sure the college lacked

infrastructure and facilities, but it made up for all that with its dedicated faculty. We were lucky to have excellent teachers in chemistry who taught us beyond the text books. Exceptional among them, KRJ, introduced us to the concept of “Research” which to us then was as exciting as a detective story. But the best was yet to come. KRJ put in all his powers of influence to coax, cajole and threaten a team of six of us to prepare for the Science Talent Exam conducted by National Council for Education Research and Training (NCERT). Despite our skepticism we were driven by his enthusiasm and conviction. He was up in the air when all of us qualified for the interview at the Indian Institute of Science (IISc), Bangalore and thrilled beyond words when three of us were awarded the National Science Talent Search (NSTS) scholarship.

From then on there has been no looking back. The scholarship provided the roadmap to postgraduation and PhD and prepared me for a career in science. In retrospect, in my life a mentor has made all the difference. KRJ taught us to overlook the deficiencies of the college, trained me to look beyond the boundaries of the village and focus on the pursuit of knowledge.

The NSTS came with several bonus points. The most stimulating were the book grant and the annual month long summer school. Both these served to sustain my interest and excitement in science. The book grant was a great incentive. I got to own classic textbooks in chemistry, some of which still adorn my home library.

The summer schools were fun too. We saw research at close quarters because these were held at institutions like IISc, National Chemical Laboratory (NCL), National Physical Laboratory (NPL), etc. We had lecture in the morning and experiments during the afternoon. During a summer school stint at IISc, we had the most memorable physical chemistry classes by Prof. AKN Reddy. We were introduced to looking up journals, following protocols, conducting experiments and analysing the results. Of course most of it was beyond us, but that didn't matter we got a great introduction to research!

I couldn't attend all the summer schools; the student unrest in the 1970's and consequent postponement of examina-

tions often prevented us from participating. Summer schools brought us close to scholars from different parts of India and the cultural evenings helped us forge great friendships!

Decades have gone by and my scientific career has taken me from academia to governmental R&D, and now finally to industry. When I do a stock taking, I find not many from our NSTS group stayed in science for long; but the few that did are firmly entrenched and still facilitate the propagation of scientific temper and culture. It is important not to make this into a number game; even at 0.1percent return it is indeed a great effort.

I benefited from the NSTS immensely, as have several of my juniors from that little village college. Let us take such schemes to every nook and corner of India; may be there is someone waiting for a spark!



23

Lucky to be where I am

Rajeshwari Chatterjee
(by K Shashikala)

I was born in January 1922 in a progressive, open-minded family, not perhaps with a silver spoon in my mouth, but surely with a book in hand! My family, a large extended one as was common in those days, were all fairly well read, even the girls, and were encouraged to take part in any activity we chose. My grandmother, Kamalamma Dasappa, was one of the very first women graduates in the erstwhile Mysore State, and was very active in the field of women's education, especially those of widows and deserted wives. In order to help the cause of girls' education, she initiated the setting up of an accelerated school syllabus, which permitted students to finish their matriculation by the age of 14 or so. This was done in the "Special English School" run by the "Mahila Seva Samaja", and some of my cousins and I went through this course. After my school finals I almost took up history as my subject, as I like reading and learning about past events even today, but since I also enjoyed studying science and mathematics, I finally opted for physics and mathematics. Going to college and university were taken for granted in our case, and I went to Central College in Bangalore for my B.Sc. (Honours) and Master's degrees of the Mysore University. I maintained a first class career

throughout and after my M.Sc. took up a job at the Indian Institute of Science, Bangalore in the then Electrical Technology Department. I worked as a Research Student Assistant in the field of electrical communications.

After the Second World War an interim government was set up in India to transfer power from the British to Indians. This Government offered scholarships to bright young scientists to study abroad. I applied for one such scholarship in the field of electronics and its applications, and having been selected in 1946, was soon on my way to the University of Michigan at Ann Arbor for graduate studies. Though I was in my mid-twenties by then, my family raised no objections to my going abroad, unmarried though I was then! Remember, this was more than 60 years ago! Many young girls today, who can walk into courses and careers of their choice, may have no idea of the kind of restrictions women then had to face, even abroad. Many universities even in the West would not admit women till the 1920's or 30's. I was indeed very lucky to have faced no such discrimination.

Working for my Master's in Engineering and later for my Ph.D. in the US was very enjoyable and I learnt many things. I learnt to be even more open-minded and receptive to new ideas. I learnt that nothing is impossible to achieve if we set our mind to it. I made many new friends and have kept up contact with some of them over the years. After I obtained my Master's degree in 1949, I went for eight months practical training in radio frequency measurements at the National Bureau of Standards in Washington, DC. In September 1949, I went back to Ann Arbor to continue my studies for my Ph.D. on a Barbour Scholarship. My advisor was Prof William G Dow, who passed away in 1999 at the grand old age of 103.

Back in India in 1953, I joined the faculty of the Indian Institute of Science, and started an active research career. I also married a colleague Sisir Kumar Chatterjee, once again with the wholehearted support of my family, and worked in collaboration with him on many of my projects. We spent most of our time in the beautiful environs of the IISc, either in the Department or in the library. Our daughter, now a professor in the US, spent her

entire childhood there.

Both my husband and I used to take up a number of projects and published several papers jointly. We also taught many courses, mostly in electromagnetic theory, electron tube circuits, microwave technology, and radio engineering and brought out several books on them. My major contribution has been in the field of antennas for special purposes, mainly in aircraft and spacecraft. I continued to write books on these subjects even after he passed away in 1994, and kept up my interest in science and particularly engineering. I have guided 20 Ph. D. students in their work, both men and women. Many of my students have gone on to become well known in their fields and have been directors and professors, in India and abroad.

Several awards and honours have come my way, including the Mummadi Krishnaraja Wodeyar Award for first rank in the B Sc (Hons), the M T Narayana Iyengar prize and the Waters Memorial prize for the first rank in M. Sc., the Lord Mountbatten prize for the best paper from the Institute of Electrical and Radio Engineering, UK, the J C Bose Memorial prize for the best research paper from the Institution of Engineers, and the Ramlal Wadhwa Award for the best research and teaching work, of the Institute of Electronic and Telecommunication Engineers. However, more than all this, I have cherished my association with some of my students and the many young people I met. I have learnt so much from all of them, many of my ideas have undergone a sea change! After retirement from the IISc, I also started working on social programmes, chiefly with the Indian Association for Women's Studies. I then saw how many women have struggled to come up in life, against all odds, which we as members of an elite class hardly have had to face. I strongly feel that as scientists and engineers, lucky enough to have reached where we are, we should do whatever is possible to help others, especially other women, who are less privileged than us to study, work, and come up in any field that they wish to pursue.



24

Believing in myself

Shubhada Chiplunkar

I was born in a joint family. Being the youngest member I received a lot of care and attention. My parents, both teachers at that time, inculcated in me the love for science and literature. I was told that there was a long debate over the choice of my school which related to the medium of instruction. I finally went to a convent school. My parents and my eldest uncle (who played a major role in shaping my career) were keen that I maintain my marathi roots. My mother took extreme care to teach me Marathi although I was attending an English medium school and this gave me the advantage of reading books in both the languages. In school I enjoyed studying English literature, history and science with the same passion. Being a science teacher my father had innovative ways of making me understand the beauty of science. I always had the freedom to express my ideas and make my choices. So I decided that I would get into a medical school. But that was not to happen and I graduated in Microbiology. I then realized that there is a world beyond medical school. We were the first batch of K.J.Somaiya College to graduate in Microbiology. The non-fiction book popular among students in those days was 'Microbe Hunters'. It had stories that described important events in history of microbiology and contributions made by the great masters. The

book fascinated me and strengthened my decision to pursue a career in science.

I applied for the postgraduate program at the Cancer Research Institute (CRI) in Mumbai. The selection process was stringent and I faced stiff competition but I was selected for the masters program. It was my first step into, research. I decided to continue for a Ph.D. degree at the Cancer Research Institute working under the guidance of (Late) Dr Mrs Kumud Karande.

I got married to Vivek at that time. I was determined to pursue an academic career, and this decision received unanimous support from all at home. Education was a top priority with the Chiplunkars so I received support from Vivek, himself a mechanical engineer. A post doctoral offer in 1984 meant I would be away from home for a few years. I resigned from the job of 'Scientific Officer' at CRI and joined the lab of Prof. Stefan Kaufmann at the Max Planck Institute for Immunobiology in Freiburg, Germany.

The postdoctoral training was a turning point. Stefan was an exuberant, dynamic and demanding supervisor. I was working with him on understanding the role of cytotoxic T cells in leprosy. In 1984, T cell cloning was a hot field. With all zeal and determination I stepped into this field not realizing the frustration and disappointments I would be facing! Making T cell clones to *M. leprae* was not an easy task for a postdoc working within a limited time frame. Simultaneously, I decided to pursue another project, on understanding the role of recombinant interleukin 1 as a B cell growth and differentiation factor. The time spent at MPI was enriching. After a year we finally got interesting results. It changed my outlook to research and I developed a strong fascination for immunology. Staying away from my family for all these years was not easy, and in 1986, I returned home with a firm decision to work in immunology. At that time CRI was engaged in anti-leprosy vaccine trials and were looking for immunologists with experience in the field. My training in mycobacterial immunology turned out to be an asset and I joined the institute as Scientific Officer in the Immunology department and had the opportunity to work with distinguished scientists Dr S. G. Gangal and Dr M. G. Deo. Working on the leprosy vaccine project proved to be a

multifaceted experience. In addition to doing basic research, this involved visits to leprosy hospitals, vaccine trial areas and helping in project administration. I was exposed to a new area of public health management. I developed my own group and decided to work on understanding the role of a unique subset of lymphocytes, gamma delta T cells in tumor immunity. It was a challenge to handle projects on leprosy and cancer, and I was lucky to have very good students and staff members forming a wonderful team! Around that time I became a part of the 'Molecular Immunology Forum'. It was a group of 'young rebels' who were keen to discuss good science outside the 'traditional disciplines'. Being a member of this group has been the most educating experience of my life. In due course, I expanded my research interests to other areas of innate immunity, understanding reasons for immune dysfunction in patients with cancer and development of immunotherapeutics (monoclonal antibodies). It was through the interaction I had with clinicians at Tata Memorial Hospital that I realized the need to have a translational component in my area of work and we initiated projects that addressed some of these issues.

Looking back upon the 25 years I spent in research as a woman scientist, although I did not face major road blocks that could steer me away from the path, I did encounter obstacles which have made me emerge as a stronger person. Gender bias did not become a hindrance, although I feel it remains a major issue which women scientists face even today. I strongly believe in my abilities and capacity to undertake challenging projects and to move ahead!



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From basic science to agricultural scientist

Renu Khanna-Chopra

As a child I always felt excited about going to school and learning new things. I went to school across several states as my father, an engineer with a government department, was transferred frequently. My parents, especially my mother, always took care to admit us to the best school in each area. We moved across U.P. and Punjab and I attended a school in a village also. I was awarded a scholarship at the primary level by the department of education in Punjab. This happened primarily due to the strict discipline enforced by my mother and her personal interest in our education.

My school education was completed in Delhi. I was fortunate enough to be admitted to one of the most prestigious schools in Delhi, Lady Irwin School, in class eight, I opted for biological science in class nine as I was very eager to learn about the basis of life, that is, the cell. The school had excellent laboratories and hence theoretical concepts were strengthened by hands-on practicals. I also participated in a science exhibition by making a model of the circulatory system of the frog.

In class eleven, I competed for the N.C.E.R.T. National Talent Search scholarship for which I prepared a project on 'Plant pigments'. I extracted pigments from leaves and petals and observed their expressions at different pH. I learnt about their chemical structure also. I was pleasantly surprised when I was selected for the scholarship which was up to Ph.D. level for pursuing studies in basic sciences. My father was transferred to Gwalior, where I pursued a course in B.Sc. (medical).

The summer schools organized by N.C.E.R.T. at Madras University and Delhi University in the summer holidays further oriented me towards a research career. The projects in the summer schools were designed to expose us to modern biochemical techniques such as chromatography, and they also involved presentation of data. N.C.E.R.T. appointed eminent professors of botany and zoology to conduct the summer schools.

I became interested in plant biochemistry and opted for post graduation in plant physiology at Indian Agricultural Research Institute instead of the conventional M.Sc. course in botany. This gave me the opportunity to conduct research on the "Mechanism of flowering in rice" and to monitor the endogenous levels of growth regulators involved in the process.

It was very clear at this juncture that I wanted to pursue a career in research and work on the biochemistry of photosynthesis in relation to crop productivity since this process fascinated me. The chairman, Dr. S.K.Sinha, an eminent plant physiologist, encouraged me to think innovatively. I worked hard and read extensively. I started publishing early and worked on several projects at the same time.

My Ph.D. research work was on Physiological and genetic basis of heterosis. As equipment for measuring photosynthesis rate in intact leaves was not available, I devised a set-up based on incorporation of $^{14}\text{CO}_2$.

My research laid the foundation of photosynthesis research in relation to agricultural crops in India. This was published as a review in *Advances in Agronomy* and subsequently became part of the text book on genetics.

After completing my Ph.D., I got married to a bank of-

ficer and took the position of C.S.I.R. pool officer at Jawaharlal Nehru University, as a regular job was not available. Upon the arrival of my son, I found it very hard to devote myself to full-time research. My mother provided the necessary support and I finally joined I.C.A.R. Agricultural Research Service as a scientist in 1978, the same year I also received the Young Scientist award of I.N.S.A. from the prime minister of India, Mr. Morarji Desai.

I am largely known for my research in the area of Photosynthesis, crop physiology and abiotic stress physiology, especially drought and high temperature tolerance.

I have been at Water Technology Centre, I.A.R.I. for the last thirty years where I have trained eight Ph.D. students and taught courses on senescence and stress physiology. Throughout my career I have focused on research, family and service to plant physiology and agriculture.

Research for me is a way of life. I remain engrossed in the experiments in which I am involved and feel a thrill if I am able to find an answer to a query.

Over the years I have won several awards and honors, including the first I.C.A.R. Best Woman Scientist Award (1995), R.S. Asana Endowment award (1983) and Platinum Jubilee Lecture award of Indian Science Congress Association (1998). I was elected Fellow of Prestigious National Academies, including the Indian National Science Academy, National Academy of Agricultural Sciences and the National Academy of Sciences, India. I received several fellowships including the Homi Bhabha Fellowship (1980), INSA-Royal Society Exchange Fellowship (1982) and the Biotechnology Overseas Fellowship (1989).

I feel fortunate to have found a niche in the area of agriculture due to my early interest in plant biology and for the continued support provided by my mother and my husband, without which I could not have realized my dreams.



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My experience with research

Joyanti Chutia

In my school days, I was equally interested in the studies of literature, mathematics and science. I studied in a rural girls high School where there was no teacher to teach mathematics in the higher classes. My father was Headmaster of the boys high school in that area. Having seen my interest he requested one of his colleagues to teach me mathematics during summer holidays when I was promoted to class nine. I was one of the first girls to take mathematics as a main subject in our Matriculation course in that school and did well in the examination. From my childhood, I was very eager to learn science; it seemed very exciting and I secretly desired to study science in college. It was also very inspiring when my father told me about the lives of great scientists like Einstein, Newton, Bose, Raman, etc. I was surprised to know that Marie Curie was the first woman to receive the Nobel Prize, because till then I thought that only men could become great scientists.

I was encouraged by my father to study science and sent me to Guwahati to Cotton College, the premier college of the North Eastern region. We had the good fortune of having some very good teachers in Physics who instilled in us an abiding love and passion for science. They stirred my imagination, describing

scientists as “Peeping Toms” at the keyhole of eternity and painted physics in such glorious colours as to make it worthy of life-long pursuit! That is when I decided to become a physicist. After graduation, I taught for some time in the same school where I studied, and then went to Dibrugarh University for postgraduate studies.

After passing the M.Sc., I joined as a lecturer in a graduate college. Although it was a very rewarding experience, I knew in my heart that scientific research was my true calling.

The Head of the Department of Physics at Dibrugarh University advised me to apply for a U.G.C. fellowship to do research in Solid State Physics. I received the fellowship and started my research career in 1976, studying conduction mechanism in thin polymer films. My research interest was further stimulated by attending national and international conferences. In the seventies few women scientists worked in experimental physics in northeast India due to lack of facilities, opportunities and also encouragement from their families: many scientifically-gifted women could not take research as their profession.

In 1980, just before submitting my thesis in the University, I went to the International Centre for Theoretical Physics, Italy to attend a research course on Polymer Physics and Liquid Crystals for three months. I continued my research for another year as a CSIR-postdoctoral fellow in the Dibrugarh University.

The scientific community of Assam, specially the Assam Science Society, realized the importance of a fundamental research laboratory to carry out advanced research in this region as early as 1959. But it took about two decades for fruition of this dream. In 1979, the society established a research centre by the name of Institute of Advanced Study in Science and Technology (IASST) at Guwahati. The institute was formally inaugurated by Dorothy Hodgkin, a Nobel Laureate, on 3rd November 1979.

This institute is multidisciplinary in character. Its beginning was very humble having to depend heavily on our hopes and dreams for its survival and growth. Luckily for me, research in Plasma Physics topped the list of priorities in the nascent research centre. This was a new area to explore in Physics, and I was initiated into this field at the Institute of Plasma Research in Gandhinagar. I spent nearly two years in Plasma Physics

Programme being carried out first in Physical Research Laboratory, Ahmedabad.

On my return I was invited to join the IASST as a faculty member and my first assignment was to set up the Plasma Physics Laboratory. It was a herculean task. I had to work without virtually any infrastructure or library. The institute did not have any corpus or regular fund. Let alone the State Government, even other physicists in Guwahati had no idea about a Plasma Physics Laboratory! Our theory group worked under a project financed by the Indian Space Research Organization and we submitted a project to the Government of Assam for funding. Our perseverance combined with the favourable reports of the experts of national level in this field yielded results and the Government of Assam provided us funds to start the experimental work. After preliminary work in the laboratory, I felt the need for more training to keep pace with the modern techniques. In 1988 I went to work in the Plasma Laboratory of the Institute of Space and Astronautical Science, Tokyo under the supervision of Dr. Y. Nakamura. My research work was very exciting and involved low frequency instability in low temperature plasma and propagation and reflection of solitary waves. Our papers published in reputed journals were frequently cited. On my return to Assam, Dr. Nakamura donated some important equipment to our laboratory that helped in developing and installing a Double Plasma device in the Plasma Physics division of the Institute.

After dedicating many years to the establishment and development of this Institute – the only one of its kind in the entire North-Eastern region, I became its Director in 2005. Only now I am facing the biggest challenge of my life, because I have to move from door to door to look for funding just to keep the Institute alive. Politicians and bureaucrats are so apathetic to scientific research that most of my time is taken up with them, leaving little time for my real job. But I am not the one to give up hope so easily. I am determined to create world-class research conditions and facilities in my Institute so that our talented young scientists can compete on equal footing with the scientists of the developed countries. I firmly believe that “study of science is an end in itself, and the path of science must be pursued for its own sake.”



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Building a career despite family pressures

Tanusri Dasgupta

I was born in Calcutta, and I am my parents' only child. I attended Bagbazar Multipurpose Government School which was close to our house. Influenced by the environment in which I grew up, my father was a Ph.D. in physics and was a physics teacher – from childhood, I was motivated to build a career in physics.

My family encouraged my school and college education. I did my bachelor's from Presidency College, Calcutta, and my masters from Calcutta University. However, they were rather conservative and not very comfortable with the idea of a girl going to a far-off place for study. This was one of the primary reasons for my staying in Calcutta after finishing my master's degree and joining the Ph.D. program at a research Institute in Calcutta. Afterwards I realized the importance of going out, seeing the world and broadening my vision. I was greatly influenced by my colleague, who later became my husband. I fought a lot to convince my parents about the importance of going abroad for post-doctoral studies. In middle-class Bengali families it was not common for a girl to stay on her own in distant places.

For post-doctoral studies I went to Paris. In the beginning it was not easy for me to be alone in a foreign city where I knew nobody and could hardly speak the language. For the first time in my life I had to do everything by myself! Nevertheless I was determined not to give up. While I did well academically, I gradually became unwell and had to move to Max-Planck Institute in Stuttgart, where my husband was a post-doctoral fellow. I was a Max-Planck Fellow on suggestion by Prof. Ole Andersen who, after my husband, has been a big source of academic inspiration for me. The decision to come back to India was also not easy. My husband got a job offer and decided to come back to India, and I came back primarily because of his decision. I consider this the most difficult part of my life.

I joined the Indian Institute of Science as a research associate but fortunately, within a few months, I got an offer from the research institute in Kolkata where I am presently working for an independent position. There was constant pressure from my family to take a job in the same city where my husband is, but I felt it was important to have my own independent research career. With my husband working in Mumbai, and me in Kolkata cities separated by about 2000 km, over the years this created severe problems which I could only overcome with my mental strength. But on the other hand, I feel I have achieved many things in my academic life including professional recognition. I built up a group, which I could not have done otherwise. To have a successful scientific career, it is important to be mentally strong to overcome family barriers.



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A woman ecologist in India

Priya Davidar

As one of the first women to become a professor of ecology in India, I was able to witness changes in the status of women ecologists in the developing world. I became an ecologist through a fortunate set of circumstances. I had an early connection with nature due to my father who was an amateur naturalist and wildlife photographer, and this gave me a spirit of adventure and curiosity about the life around us. I was also privileged in being able to do my doctoral research under the guidance of Dr. Salim Ali, who was an eminent ornithologist and one of those rare individuals with a passion for enquiry and an absolute sense of integrity and fairness. I was a young woman in my early twenties launched into a male dominated field, where women were conspicuous by their absence. My interest in ecological research was not taken too seriously by many of my colleagues. However, Salim Ali gave me unstinting support, completely disregarding gender as being of any significance to research involving fieldwork. This gave me the courage to carry on regardless of opposition or indifference.

Looking back, I can see that having support from established scientists played a very important role in my life. After my Ph.D., I was a postdoctoral fellow in the United States for over

seven years. I was associated with reputed institutions such as the Smithsonian Institution and Harvard University, among others, and had the opportunity to carry out field research in North and Central America. I received support from many outstanding scientists: this is what helped me to get established in science. This underlines the importance of mentorship in science.

When I returned to India to take up a faculty position at Pondicherry University after being abroad for 7 years. I faced an academic life that was quite overwhelming in its brutality. However, there were many positive aspects, which helped me pursue research and teaching with interest and enthusiasm. I can identify some reasons for the difficulties I faced. Firstly, the caste system is still alive and doing well. As a proof, most of the elite institutions are dominated by the upper castes, and although statistics are lacking, caste-based nepotism is very much a part of academic recruitment procedure. In the Universities, however, because of reservation, there is a greater diversity of castes. Gender is the other issue: women have a subservient role in society and this is translated into a subservient role in the workplace. As in Western countries, women are not as much a part of academic networks, which are important in furthering careers. Social status is further undermined if body language, dress code and hairstyle do not conform to tradition, particularly in the conservative south.

How I survived and achieved a fairly successful career seems a mystery! It is a cliché but India is truly the land of paradoxes. The Indian experience has given me courage and fortitude to pursue my goals regardless of opposition and lack of peer support. I also was in a field of science that does not require infrastructure and laboratory support. Many of my colleagues in the lab-based sciences are languishing due to lack of basic infrastructure and administrative support to carry out their research. I had the good fortune of having a supportive family atmosphere, good students and international recognition. I have trained many students and many of the women have distinguished careers of their own. Female ecologists are well accepted by the rural population. They usually get extra support and in more than 20 years of teaching, we never had an incident of violence towards students even in the

remotest places in the jungle. Wherever I travel in the world, I have the good luck to meet up with at least one of the former students of my Department, who have been carrying out interesting and innovative projects.

Ecologists have an important role to play in improving the quality of life in India, where environmental degradation and loss of biodiversity is pervasive. Young ecologists are now taking the lead and with their vision and intelligence, are making changes both small and large across the landscape that is India. This is the hope for the future.



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The pursuit of science – my hobby and profession

Deepti Deobagkar

It is said that you cannot choose your parents. I was extremely fortunate to have been born the daughter of Manik and Pandit (Waman – known as Pandit because of his sharp mind) Achwal, who did not believe in conditioning their daughters. I rarely ever heard statements like ‘You are a girl and you should do so and so and not do XYZ,’ and in fact never heard them at home. In addition, I was left alone to explore and learn from my own experiences, and was never told what to think. My parents were always pillars of support when needed. They also inculcated the idea that one is capable of anything and there are no limits except the ones that exist in our own minds. My mother often cited a story where it was said that the word “impossible” did not exist in Napoleon’s dictionary. They imbibed a lot from European culture and society where they had spent a substantial period of time, and they tried to combine it with the best practices in our country while dealing with day-to-day matters. Being their first daughter and the only one for seven years, I was a very quiet and shy person, and spent hours on my own, daydreaming and imagining things.

Initially, because of my liking for reading, I even toyed with the idea of taking up arts and psychology. My father was a

scientist (a textile chemist) and a professor, and his attitude to science and life left a deep impression on me. There were inspiring and dedicated teachers in my school, college and later life, and I owe a lot to them. My mother insisted on my reporting things which I noticed and encouraged me to wonder about them and to discuss and share them. I faced no difficulties and always got encouragement from my parents. My aunt, also a scientist working on cancer, stayed single for many years in order to do research. It thus was natural for me with my temperament and background to choose science as a profession.

The living world and the amazing capabilities of microbes to influence it were my early interests. The time spent in Cambridge and Berlin while I was a student was important in shaping my ideas. In Cambridge, I learnt about the world of preimplantation-stage mouse embryos and relished the charged atmosphere. In Berlin I learnt of the relationship between hemimethylation, chromatin structure and regulation of gene expression. The development of a single cell into an embryo and then into an organism which has the potential to create artifacts was an interesting subject. Although it is the genome which seems to have the blueprint, the ability of the environment to influence through epigenetics, the phenotype, behaviour, physiology and even intelligence of an individual held great promise in my imagination. Among other things, this is what I have been working on for the past 28 years.

While pursuing my Ph.D. at the prestigious Indian Institute of Science, Bangalore, I met my future husband, Dileep Deobagkar. He had just left a sound and prosperous career in USA (at NIH and Yale), declined job offers and come to India as a research officer without any permanent job in hand! His forthrightness, passion for and dedication to science impressed me. He has since helped me in research and science writing and has taught me many things. Support from Dileep in every possible aspect of our life, and his trust and confidence in my ability to multitask have been the main factors that enabled me to continue research while making a home and looking after my daughters. We often take each other's support for granted. At times it was the sheer passion for science, and my inability to even imagine an existence

where science was not part of my life, that kept me going when things were tough.

Why do I do science? I find it fascinating and satisfying. When one reads about really good experiments, looks at unraveling of the human genome, the possibility of asking many meaningful questions and perhaps getting answers, it is very inspiring! My years as a student were very nice. When I started working, however, I faced difficulties for several years. In addition to challenges in my personal life, there were many in the workplace. I had decided a long time ago, particularly when I joined the University, that I would do science only because it is enjoyable.

For me, science and the scientific attitude have always been a way of life. My work on biosensors and nanotechnology, science popularization, and genetics and epigenetics excites me a lot. As a university teacher, one is constantly surrounded by young and bright students. I have learnt a lot from my interactions with M.Sc. and research students and I find it challenging and rewarding. As a consultant to the Serum Institute of India, I have also been able to get a good feel of the biotechnology industry and business. My chosen profession involves the pursuit of science and I am indeed happy that I can earn my living doing it.



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Does it really matter that one is a woman scientist?

Aruna Dhathathreyan

My images of a scientist came from the wonderful books of Jules Verne that my uncle got me to read when I was a schoolgirl of eight or nine. I read each of them at least two to three times and dreamt that I would also one day journey to the centre of the earth or save mankind from an invading microbial colony from outer space!

I think I was lucky to be born in a family which had grandfathers who were teachers, a mother who wanted more than anything else to educate her girls, and a father who did not interfere with his wife's ambitions. My early years in school were mostly marked by some very good science teachers who encouraged me to ask questions. I initially wanted to study science only because I had romantic ideas about helping the poor people in my country by being a good teacher!

Girls of my generation usually did not think of a lifelong career and took up a job in a bank or became a teacher because this career path was considered to be 'trouble-free'. My parents supported my decision to take up a career in science. However, they also worried often about their decision of letting me be a

researcher, especially when a neighbour's daughter got a job in a bank or when someone's niece got engaged to be married. They were often criticized by relatives and friends, and I was told by these people that whatever a woman did, ultimately her role was that of a good wife and a mother!

Out of a class of fourteen students who did their undergraduate programme in physics, only four of us went on to a postgraduate degree and I think I was the only one who went on to complete her Ph.D. I think I chose science, especially physics, because I loved the fact that one could explain so many things in everyday life and if one was only curious, one could go on discovering why and what made the world go round!

At college I found that an overload of abstract ideas was not for me and I loved experimental physics more than anything else. I realized one need not be a genius in theoretical physics, or even be mechanically handy. One only had to wish to find new things and have the strength to work on an experiment where no one had yet found an answer. The greatest joy is when you are the first person to get to the answer. Today, I often tell my Ph.D. students that the nice thing about being a scientist is that you get paid to do something you enjoy. I do not think any other job gives you this luxury.

I completed my master's in Physics with electronics as my special subject, and when I went to register for a Ph.D. programme I decided biophysics would be the area of my research work.

After completing my Ph.D. in biophysics, I went to Max-Planck Institute for Biophysical Chemistry, Göttingen, for post-doctoral work. In the meantime I had married a chemist who supported my passion for research and encouraged me to be scientifically active. He shared the childrearing effort as much as possible. For almost four years after our marriage, I stayed in Germany while he worked in Canada, and we thanked Thomas Graham Bell for inventing the telephone that kept us going all through those years!

My years at the Max-Planck Institute were enriched by excellent teachers and scientists like Hans Kuhn, Manfred Eigen and Erwin Neher, who showed me how interesting science could

be and the wonderful world we could explore through experimental work. My important contributions during this time dealt with development of new experimental tools to study molecular assembly processes at interfaces and in lipid-protein interactions. Switching from physics to biophysics to physical chemistry or even sensory physiology was made easy and interesting due mainly to the great teachers I worked with. My rewards have been my class of enthusiastic graduate students who rushed to attend my course in experimental techniques in biophysics or spectroscopy and voted me an excellent experimental physicist!

I realize the first few years in the career of a scientist are important and women scientists need to avoid falling behind their male colleagues during this crucial period. Due to the traditional role of child-rearing or care-giving expected of women, often women do get left behind. I have been lucky in that my husband and I share an enthusiasm for science and this has helped me tremendously in my career.

I am presently a scientist in a national laboratory, fortunate to have had excellent mentors, who have inspired, encouraged me to do what I wanted. This freedom to explore has helped me to mature as a scientist.

I have benefited greatly from my students. Their questions and curiosity have helped me to explore new areas in science.

Of course, being a woman scientist has not always been easy because one has had to make difficult choices in life. I think some of my fellow women scientists would agree that we go on a constant guilt trip because we think we are not doing justice to our roles as mothers or as scientists. Society still stereotypes women in certain roles and does not expect us to break from them easily.

To be accepted as a scientist who happens to be a woman is still an uphill task in some areas considered a man's world! A woman is expected to be docile and not ask too many questions. Even where women are allowed to study and work, some roles are still assigned to women by men. This often acts as a deterrent for young women who may have wished to take up careers in science.

If we could free ourselves from such prejudices and approach science with an intellectual objectivity, it may be

possible to do outstanding scientific research. To go on working passionately in science requires the support of the family and society, especially for women. For me this has been possible mainly because my son, my husband, my parents and my entire extended family have stood by me and have helped me to go that extra mile. Not all moments have been great. I have had to face setbacks and challenges. However, the freedom to be open, to enquire with the curiosity of a child, and to understand the world through science has been a wonderful privilege! In the world of science any discrimination or prejudice has no role to play and I hope women as well as men will be allowed to live by the same rules.



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My tryst with the monsoon

Sulochana Gadgil

Pune where I was born and brought up has for a century and a half been in the forefront of the struggle for the liberation of women. My grandfather, a physician, was a freedom fighter, and many of his fellow participants in the struggle against the colonial rule were regular guests at our house. My father, a physician with an M.D. in allopathy, had also studied the Indian systems of medicine, Ayurveda and Yoga, in depth. My mother was one of the members of a thriving group of women writers in Marathi.

I am the third of four daughters. My parents encouraged us all to study and take to learned professions; two of my sisters are physicians. I also did well in school and college, so I was destined to become a professional!

I studied in a primary school in Pune, before moving to Rishi Valley for my high school education. At Rishi Valley, we were encouraged to study what we wished, as we wished, without any pressure to score good grades. I adopted the same carefree approach for my undergraduate studies at Fergusson College, back in Pune. Madhav, the fellow student whom I eventually married, claims that I caught his attention when jumping out of a high French window of a lecture hall to escape from a boring class! I had enjoyed mathematics from a young age and decided to

continue in the science stream rather than joining an engineering college. I went on to do a master's degree in Applied Mathematics at Pune University. At this juncture, I became engaged to Madhav who comes from an academic family. From the outset he was keen on both of us actively pursuing a career in science.

Madhav and I felt that a sound foundation for such a career might be laid in a good university abroad and luckily we were both admitted with scholarships to Harvard. I was a graduate student of applied mathematics, and with my interest in the natural world, decided to work in physical oceanography with Prof. A R Robinson. The course work equipped me with an excellent grounding in applied mathematics and physics. Because of Madhav, I also developed an interest in mathematical ecology and evolutionary biology and began some work in that field. Amongst the many advanced courses I took, one was on planetary fluid dynamics, taught by Prof. Jules Charney, who has made fundamental contributions to tropical meteorology. After my Ph.D. I decided to focus on the monsoons, surely the most challenging problem in tropical meteorology and of such vital concern to us. So I did a year's post doctoral work with Prof. Charney at MIT. During my graduation days, there was an outstanding group of geophysical fluid dynamicists between Harvard, MIT and Woods Hole Oceanographic Institute. Perhaps the most important part of my education at Harvard and MIT was learning the art and science of modeling of complex systems from stalwarts in the field. This gave me the confidence to undertake modeling studies of not only the monsoon, but also of crops and to develop simple models for the impact of pests and diseases on crops in a variable climate.

In 1971, Madhav and I came back to India and for two years I worked as a CSIR pool officer at the Indian Institute of Tropical Meteorology. This gave me an opportunity to learn from the great tropical meteorologists like R. Ananthakrishnan and to work with the distinguished monsoon meteorologist D R Sikka. Thus began my lifelong passionate involvement with the monsoon. Fortunately for me, Satish Dhawan, then director of the Indian Institute of Science in Bangalore, was fascinated by the monsoon as a challenging problem in fluid dynamics. So he

recruited me as one of the members of the newly founded Centre for Theoretical Studies (CTS) comprising an interdisciplinary group of scientists engaged in modeling complex systems, including biological systems, the atmosphere and the oceans. Madhav was also hired as a mathematical ecologist at CTS. Out of these beginnings grew the Centre for Atmospheric and Oceanic Sciences (CAOS). CAOS has made very important research contributions and played a major role in the formulation and implementation of the Indian Climate Research Programme, providing leadership for major observational experiments over the surrounding seas in the raging monsoon.

Over the years, in collaboration with many scientists at IISc and other institutions in the country, I have studied the 'How and Why' of monsoon variability, with analysis of conventional and satellite data and investigations of models of varying levels of complexity to understand the mechanisms responsible for important phenomena. I have worked on the formulation of the methodology for application of the knowledge and prediction of rainfall variability for farming strategies and also on modeling ecological and evolutionary phenomena. One of the most satisfying pieces of work involved a study of the daily satellite imagery of the Indian region and the surrounding seas which led to the discovery of a basic feature of the sub-seasonal variation in the monsoon cloud bands. We showed that in each monsoon season, cloud bands are generated over the equatorial Indian Ocean and move northward to the Indian region at intervals of a few weeks. This demonstrated that the variability of the monsoon is inexorably linked to that of the cloud systems over the surrounding ocean. Our endeavour to understand what leads to the variation of cloud systems over the tropical oceans led to another important discovery: the presence of a threshold for sea surface temperature above which there is a high propensity for occurrence of cloud systems. The validity of both these results obtained from analysis of the first satellite datasets has been confirmed with the better quality datasets now available. From these studies we have also demonstrated that the monsoon is not a gigantic land-sea breeze (as we are taught in schools) but instead is a manifestation of the seasonal migration of

a planetary scale system which is seen over non-monsoonal regions as well. I am particularly excited about the recent work in which we showed that the variability of the monsoon is linked to that of cloud systems over the equatorial Indian Ocean. It may be possible to use this link to enhance the skill of monsoon predictions. Since we meteorologists always stress the importance of studying the monsoon in an agricultural country such as ours, I tried to learn from farmers in the semi-arid tracts of Karnataka whether information and prediction of rainfall variability could, in fact, lead to enhancing production in the rainfed tracts. In collaboration with the farmers we have derived farming strategies which are tailored to the rainfall variability of the region.

I have thoroughly enjoyed trying to develop a comprehensive understanding of the monsoon, a tantalizing mixture of order and chaos. I have never participated in the scientific rat race. Yet my contributions have more often than not, received the recognition they deserved. I believe that active encouragement from Madhav, who always had more faith in my abilities than I did, has played a crucial role in whatever I have achieved. I have been fortunate in having a wonderful family. We have a vivacious daughter, a journalist who also teaches Spanish. She is married to an innovative and enterprising mechanical engineer. They have two lively daughters who are a source of unmitigated joy. My son is a dedicated mathematician with wide ranging interests, and has made critical contributions to two of my recent papers. He has married the daughter of another meteorologist. She is currently doing a Ph. D in management sciences. As a family we share love for nature and I have spent many a happy hours with them watching birds, butterflies and elephants as well as clouds, stars and comets.

I have always been treated as a capable scientist who happens to be a woman rather than as a woman scientist, and never experienced any gender discrimination. Over the last three decades, as a working scientist in India, I have never witnessed any discrimination against women whether in selection of students or for jobs, or in assessment for promotion. In this congenial atmosphere, I believe that women have every opportunity to achieve their potential as scientists.



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It's been an interesting journey

Rohini Godbole

I come from a typical middle-class Pune based Maharashtrian family, wherein intellectual pursuits were always encouraged. My mother started her teaching career in the prestigious Huzurpaga High School in Pune, after having completed B.A and M.A after the birth of three daughters and then a B.Ed. I had a grandfather who had decided not to marry off his daughters before their matriculation and a grandmother who, in spite of having studied only up to the fourth standard, was the only relative to send me a letter with a question after listening to my interview on the radio. So clearly I had a family which saw nothing odd in girls pursuing a career. In fact among my three sisters one is a physician and two are science teachers. However, even though the family had a few doctors and engineers, there had been no scientists. Frankly, for a long time, it had never even entered my mind that being a scientist can actually be a career option.

This was probably because till the seventh standard we were taught in school only home science as I was in a girls' school. While preparing for the State Merit Scholarship (which had General Science as a part of syllabus) in the seventh standard I first studied physics, biology and chemistry, and that too on my own. I

was the first student of my school in many years to get the scholarship. But then our mathematics teacher, Mrs. Sohani invited me home to study mathematics and science with Mr. Sohani. I can still remember the innumerable chats and discussions we had and the various things Sohani Sir taught us in his unique style. I then started reading science magazines, participating in science essay writing competitions and learning things outside the textbooks.

Then one day my elder sister brought home a pamphlet about the National Science Talent Search (NSTS) scholarship programme, the one condition being that one had to join basic sciences. Since I had already decided against professional courses this was no problem. It was because of this scholarship that I could spend my summer vacations (while doing my B.Sc. on Physics from the Sir Parshurambhau College, Pune) in prestigious institutes like I.I.T. Delhi, I.I.T. Kanpur. There I met my fellow travelers on this journey, some of whom became lifelong friends! Though I still didn't have a clue as to what exactly research meant, all of this definitely increased my curiosity about it. I finished my B.Sc. and topped the university. I remember receiving an offer for a job from the Bank of Maharashtra, offering me nearly as much as my father earned that time. I like to think of the salaries offered by the I.T. sector today, dissuading the youth from going into science and research as an enhanced version of the same!! Looking back, my decision to choose research over that job gives me no regrets. I took my first step towards research when I did my M.Sc. in I.I.T. Mumbai. The professors there (especially Prof. S.H.Patil) taught me to look beyond books and to find answers to my questions myself.

My Ph.D. application abroad was quite unplanned and accidental!! In my second year of M.Sc., the American University Women's Association (A.U.W.A.) had declared scholarships for girl students for studying in the USA. To be eligible for the scholarship, one had to be admitted to an American university. Although finally I didn't get the A.U.W.A. scholarship, the application process it triggered brought acceptance with assistantship and I joined Stonybrook University to do research in particle physics.

My family had never treated girls differently, and so I never

thought I was doing anything different or special in going abroad for my Ph.D. Some relatives and acquaintances did of course try to 'warn' my parents of the problems it would create for my marriage chances! But fortunately my parents paid no attention to it. It is thus undeniable that the support of one's family, especially one's parents is extremely essential for girls choosing a field like research.

After finishing my Ph.D. I returned to India. Although I had a job offer for post doctoral research in Europe, after five years abroad I wanted to come back home. If I had taken that offer, my life would perhaps have taken a different turn. Truly speaking, I have no regrets about this decision either.

After my Ph.D. I spent three successful years in the Tata Institute of Fundamental Research in Mumbai and then started working as a lecturer in the Mumbai University. All my seniors in T.I.F.R. felt that was the end of my research. This is a sign of the vast difference between research institutes and universities in India. The first taste I got of this was at the time I requested accommodation. Whereas in T.I.F.R. I had accommodation immediately after joining, it took three to four years in Mumbai University. In the process, I had to answer completely irrelevant questions like whether I was married, where my parents lived etc.

I could continue my exploration in Particle Physics, by leading a 'double' life and due to the cooperation of my erstwhile colleagues and research students from T.I.F.R. who made me welcome in the group. Equally important was the encouragement and support received from my head of the department Prof. Rangwala, who believed in my abilities and my thirst for research. Such moral support in the early days goes a long way to give a young researcher the required confidence. During this early period, when in Poland for a conference, a Japanese scientist, after inquiring whether I had authored a piece of work, bowed down to me in the middle of Frankfurt Airport and said, "I respect that work"! I must say it did wonders to my self confidence. The support and trust of my friends and family in this period played also an essential role. With all this, things moved well in my 12 years in the Mumbai University. I could create my own niche in the field of particle physics.

I work in the area of high energy physics phenomenology; the subject of fundamental constituents of nature and how they are put together. Currently I work on theoretical aspects of physics studies at the Large Hadron Collider at CERN, in Geneva.

The satisfaction and joy I felt when a prediction one of my young German colleague and I made was found to be true and called by some as the 'Drees–Godbole Effect', or when another of my predictions with another (female) colleague was called 'Godbole–Pancheri model' was unparalleled. Some awards, honours also came along the way. The one which is very close to my heart is the I.I.T. Distinguished Alumnus Award. When the place where I took my first steps in this field says, "We are proud of you" it fills me with happiness. An appreciation of research in basic sciences from an Institution like I.I.T. which is full of distinguished alumni with glittering achievements in technology and being the first woman to get this award was particularly satisfying.

Along the way I also conducted a marriage for about 12 years, with a German colleague, across two continents. We decided to postpone having children till we could find jobs to live together and that never happened. Not having the children is perhaps the one regret that I have. Combining a happy family and a successful science career requires a large dose of luck for a woman, given the (lack of) support structures, institutional and social. Further, I must also say that I find it difficult to analyse objectively the role that the gender(bias) might have played in the struggles of establishing one self as a scientist, but I certainly can not say none existed.

I don't think of this journey as easy or difficult, but rather I feel it has been interesting. That is why I feel that it is one's responsibility to help increase the interest and curiosity about science and research in today's Indian youth and particularly the young women. I am personally involved in many such efforts. This is my way of giving back to the field which has given me a lot over the years.



33

A tale of two lives

Srubabati Goswami

I am lucky to be born in a family where one is allowed to pursue one's own interests irrespective of one's gender. I developed an interest in mathematics and science in school and chose the science stream for further studies. I worked in Neutrino Physics for my Ph.D. with Prof. Amitava Raychaudhuri in the University of Calcutta. It was an upcoming field and I enjoyed my work a lot. I got married during my Ph.D. period to another physicist. It was my own decision.

Two years after my marriage I submitted my thesis and applied for a postdoctoral position in the institute where my husband was working. However, it was not clear when the selection interview would take place. I was allowed to use the facilities there and I even had an office space. However, I soon started facing difficulties since I did not have any affiliation. So I started applying to other institutes in India for a postdoctoral position and I got an offer from TIFR. However, I was expecting at that time and because of my health conditions we decided that it was best for me to go back to my parent's house for the delivery of the child. The interview for which I waited for seven months was held soon after my departure.

My daughter was born on 27th July, 1997 and within a few days I came to know that there would be a second interview in

my husband's Institute in early September. I managed to attend this interview and got selected.

Finally, I joined as a postdoctoral fellow in January 1998 after about more than a years break. To come back to physics was not easy, specially with a small child to take care of.

After completion of one year I had to give a talk for the renewal of my fellowship and I got a positive feedback from the committee. However, the head of the group wrote in my report that I was irregular and not punctual and so my postdoctoral fellowship should not be renewed. Thus, once again I faced the possibility of termination of my career just within one year of restarting it. I was working very hard during that period. I used to go to the institute even on holidays. A question mark on my sincerity at that stage was the last thing I expected from someone totally unaware of my work or what could be its possible impact. But at that time I was feeling very confident about the work and I thought that I should not deviate from my goal. Despite the objections finally I was given an extension. I completed my tenure there and in January 2000 I joined Saha Institute as a visiting fellow.

My work started progressing very well at this stage. I had the support of my family and I could work for long hours. But in 2001 my husband told me that we should admit our daughter to a school where he was staying as later getting admission to the school would be very difficult. So I came back to stay with him, taking leave from Saha Institute. This was a very crucial point in the field in which I was working, with a lot of new results. So I decided that the work should not stop. At that time I worked from home, from cyber-cafes and we wrote a paper analyzing these results. This paper went on to become a top cite.

I take this opportunity to express my gratitude to my collaborators Sandhya Choubey and Abhijit Bandyopadhyay without whom I could not have done in this period. In between, I had applied for postdoctoral positions abroad and had got offers from Portugal, Spain and Japan. At the same time, I got a job offer from Harish Chandra Research Institute (HRI), Allahabad in March 2002. I decided to take up the offer.

I joined HRI in April 2002 and after that I never had to

look back again. We stayed on campus. The atmosphere was friendly and progressive. The academic environment was excellent. I enjoyed myself, my work and everything very much.

These years were termed as the golden period of research in Neutrino Physics. There were remarkable results from several experiments establishing beyond doubt that the invisible particles called Neutrinos are massive. This was a very important result that compelled us to think beyond our standard ideas. Our work in this field was highly appreciated worldwide.

After the struggling period from 1996–2002, it was like a golden period for me also. Of course I was not staying with my husband. It was difficult for me and I think more so for him as he was alone. But we managed. In our separate lives we were happy which, I found, was much better than staying together with one person sacrificing the career and remaining unhappy. We accepted life as it came to us and tried to make the best out of it.

My decision to come to Allahabad was a very tough decision. My husband, I feel, wanted very much to be with our daughter. However, he did also realise that I had to take the job. My husband had once told me, 'if you want to build your career do it on your own strength. Do not depend on me or anyone else for that.' Today I am very happy that what I have achieved, I have achieved it on my own. Of course, being in HRI has made it easier and having my daughter around has added a totally new meaning to my life and has made it worthwhile. In 2007, I was offered a faculty position in the institute where my husband was working and where I am now based.

This has given my daughter the chance to stay together with both parents – a chance that perhaps she deserved much earlier.



34

Dream your own dream

Rama Govindarajan

The stars shone down on 47 weeping girls, while a gentle sea breeze could do little to help them. On this evening of drama, the prosaic words “housewife”, “graduate” and “bank employee”, were being scrawled in autograph books under “Your ambition is to become a ...”. And no, the overweight, under-confident specimen occupying the schoolyard for the last time did not scribble “research scientist”!

Not even years later did I understand what the term meant. What does it feel like to be one today? My website talks about the science I do, so I’ll only say here that I completely love it. However, I did not know this when I started out. All I wanted to become was a “regular guy”, which to me and my peers meant having enough money for a gracious life-style and being in charge of a group of people, preferably large. First big mistake: borrowed objectives.

Dear reader, if you are young, please dream your own dream. Also, please, please dream big. My grandmother, Alamelu, did, for me. She also set an example by fighting tooth-and-nail for what she believed was right, and by never obeying a rule of which she was not convinced. As a young bride, *circa* 1920, she risked ostracism by her community to cook and eat *meen-*

kozhambu with a Dalit family in their hut. My other early influence was my mother, Shakuntala, practically a single, working, parent, who made light of an extremely tough life to create a home where poetry and laughter ably substituted for luxury. My only regret is that my achievements fall far short of her sacrifice.

Doing a B.Tech. at Indian Institute of Technology (IIT), Delhi was a simply superb experience. I was given the opportunity to study rather than memorise, and had the fun of discussing science with peers. Like many other girls in IIT, I emerged near the top of my class, picking up self-assurance, a “can do anything” attitude, and many close friendships. It would be good if within the next few years, half of every IIT class would be girls – it would be a change from when I was one of 54 in the chemical engineering class!

My Ph.D. advisor Prof. Roddam Narasimha, has been the biggest influence on my scientific career. Apart from fluid mechanics, he taught me to do science the right way, which for him includes a thorough and critical understanding of the subject, extreme care in methods, and zero exaggeration in making claims. I also like his conviction that the youngest student in a group may be right in a scientific discussion.

I am also blessed with a home completely free of gender bias and its manifestations. So, what can go wrong when one has the best education and heavy-duty determination, and is surrounded by good people? Read on.

I am an engineer first, and fluid dynamics has always been a favorite, but my career in research began almost by accident. When I graduated, I wanted and got a plush job, in Mumbai. Every morning I became part of the compacted mass of humanity in the ladies compartment of the 6:57 fast train to Andheri. Soon the mass revealed itself as having faces, lives, and stories. The one common theme in the stories was the incredible hard work and determination involved. These women – executives, secretaries, fisherwomen, new mothers, very-soon-to-be-mothers, many malnourished, some from home-lives too terrible to describe, running top-speed across the overbridge at Grant Road at 6:56 a.m. – are my role-models and I think back to them every

time I imagine I am having a hard time. An important ingredient for success is the willingness to push yourself to work really, really hard.

It took me two months on the job to realise that something a lot less plush and a lot more mentally demanding would suit me better. I then did a Masters in the U.S., which did not launch me into the planned orbit in industrial R&D, maybe because I soon tied myself by marriage to one city. A guest at my wedding remarked that Bangalore (as it was then) was not at all the place for a chemical engineer, and how right he proved to be! In my efforts to leave no stone unturned, I went to dozens of interviews within the next couple of months, looking for unsuitable jobs. I finally took one of them just to put my share of rice on the table. The really big mistake: not realising that the world offers myriad choices for a young couple in search of two good careers. Just don't be scared to experiment, to spend a few years as a nomad. Don't feel guilty if your spouse has to make some temporary sacrifice as well. It would be best if you can postpone marriage to the post-nomadic stage!

It dawned on me that to succeed in Bangalore, I must redefine myself. The software industry was in its infancy, but I decided, maybe stupidly in some people's opinion, that I would not be part of the big boom which I didn't know then was coming. I went into the defence-related aerospace industry instead. Here, I wanted my experience with process control and computing skills, to be put to use to avoid importing control algorithms. The set-up of the industry made this wish impossible to fulfil.

So, four years after my B.Tech., I finally turned towards research in fluid mechanics, and have never in the twenty years since then wished to do anything else. For ten of these years I worked in a national lab, during which I also completed my Ph.D. and postdoctoral work. The last ten years in academia have finally been the "real thing", this was an extremely lucky break, since the place I work, the Jawaharlal Nehru Centre for Advanced Scientific Research (JNC), came into existence at the right time for me! In my experience, independence and constant exposure to other researchers is crucial for doing basic research, and for these, an

academic institution is unbeatable. A typical national lab has other main objectives to fulfil, and cannot be expected to focus on basic research in the same way.

If you are the type who likes every day to be different, scientific research is the career for you. If you like working with young people with bright ideas, who keep you on your toes, and if you like teaching yourself new concepts, this is the career for you. If you are prepared to toil long and desperately for the dazzling discovery you are not sure you'll make, this is the life to choose! Even on a bad referee-report day, I am happy I do science!



35

Lilavati's daughters: today's story

Neelima Gupte

Many things have changed, for Lilavati's daughters, since Lilavati's times. Even so, very many aspects of her story find resonances in their lives. First, the positives. The fact that women are underrepresented in the scientific work-force was itself not recognised some years ago, let alone seen as a worrying phenomenon.

This has changed completely. All decision making bodies, whether institutions, or academies, or government departments, now feel the need to pay attention to this issue. This is quite different from what previous generations of women experienced, even if it was mostly unintentional.

In IIT Bombay, where I was an M.Sc. student in the seventies, the faculty was happy that some of the M.Sc. batches had nearly 50 per cent of girls. Our teachers were also conscious of the fact that women were seriously underrepresented at the faculty level (one woman in the physics department then). However, they thought this was the unchanging natural order, and did not consider it a part of their responsibility to bring about the change. All this is no longer true, anywhere.

I won't say much about the problem that women face at the entry level, since this is well known and much discussed. Speaking for myself, I by-passed this problem, having had the good fortune to get a faculty position at an early stage, at the University of Pune, which not only had a very active physics department, but also had a double digit number of women faculty (I was the tenth!).

This was a unique situation, and unfortunately this still remains unique. However, those of us who were there found a great deal of support from each other. Additionally, this was a very cheerful department with people who were ambitious in their work. This really helped me to grow in my early years, and even more crucially, helped me to change fields to an area that I had zero exposure to before. It is important to note that this was neither a well-funded nor a well-known department. It just had people who had a can-do attitude. Finally, this is what counts.

All this sounds good, however, there were other headaches. My husband and I worked in different cities (Chennai and Pune, not exactly nearby) for ten long years. Here again, I must acknowledge support from both my family and my husband's. Had they brought pressure on us, I might have quit, as have so many women.

Meanwhile, the job scenario was singularly unhelpful to couples trying to work in the same place. Finally, I moved to IIT Madras, which turned out to be fortunate. The institute was undergoing a sea change, and I found my own niche there. Meanwhile, the change was painful.

I was placed at an inappropriate level, perhaps because I was not in a position to bargain, something that happens frequently to women. My surroundings were far more conservative and bureaucratic than what I was used to. The people who saw me through the change were my research students, who had moved with me. They also felt uprooted from where they belonged, but somehow, by holding each others' hands, we made it through the transition.

As I said before, the problems faced by junior women faculty are now well recognised, if far from being solved. This is not to say that women at all other levels do not face their quota of headaches. Women in middle levels fight to keep their heads above the water, both as people and as professionals. They are both se-

nior and junior at the same time! That is, they are given responsibility without autonomy. Women at senior levels are frequently expected to be compliant by their senior colleagues, and pushovers, by their junior colleagues.

Harassment issues exist in many places, and are rarely dealt with in a professional way. Serious positions taken by women on issues of importance are resented far more than similar positions taken by their male colleagues. Role models who have successfully handled these problems are few and far between. However, many women manage to cope, by developing their own networks, and relying on them for advice and support. Lilavati's daughters get by, with a little help from friends.

Finally, what would we, the women of this generation, like to see for the women of the next generation? Perhaps the ideal situation would be if they were in a position so advantageous, that they would wonder what all the fuss that we make had been about. In that case, those of us who are still around then, might have to remind them that freedoms which are not guarded jealously, have a tendency to slip away!



36

In search of equality

R J Hans-Gill

I was born in 1943 at Mohie (Ludhiana) in Punjab. My father Gursher Singh Hans was a doctor and he was posted in rural areas, so I spent my childhood in small villages in Ludhiana district. My mother, Gurdeep Kaur, was a housewife who continued her education privately and through correspondence courses after marriage. I was sensitive to the uncertainties of transfer and did not really like to move, but my experience was that we always moved to a better place ! The opportunities for education for girls were non-existent in villages: there were no schools for girls, and girls were not allowed to join schools for boys. So the first few years of my life were spent studying at home, longing to go to school. My parents encouraged and guided me in learning. Sometimes, I had the opportunity of going to school and attending classes unofficially, since my father knew the headmaster. I enjoyed these visits immensely.

I became intensely aware of the problems of women in our society while overhearing the hospital staff discussing these problems with my parents. From childhood I wondered why girls were not sent to school, why women did not have jobs, why they were discriminated against in all walks of life. I spent many long hours thinking about such topics and dreaming of a new world

where equality prevailed. So, very early in my life, I had somehow formed the idea that to overcome such problems one must study and get a job. Of course, I wanted to be a doctor like my father.

My father was transferred to Isroo when I was about six years old. This village boasted of a primary school for girls. The school was housed in an enclosure which had a large room and a courtyard. After an informal test I was admitted to the fifth class. Only one teacher somehow managed all the classes, so very little was taught and I was not interested in it. All my classmates were much older than I and did not like the fact that I knew much more than they did, so I had no friends. I was immensely bored but continued going to this school since it was the only available one. Then for one year I studied English, Arithmetic and Punjabi at home. My uncle Narsher Singh, who was naib tehsildar at Balachaur, very reluctantly agreed to let me stay with him and study at a school for boys, where I could only go posing as a boy. This was a secret between our family and the headmaster. My uncle was totally against the education of women and it was only after many requests from me and my father that he decided upon this course. I enjoyed wearing a turban and going to school with my brother !

Regular schooling for me started only when my father was transferred to Gujjarwal in 1953. This village had a high school for girls and I joined the eighth class. I found that in general, schools for boys were better equipped, and had better standards and facilities. This seemed very unfair !

Unfortunately, science and mathematics were not taught at my school, and noticing my interest, my father decided to help me in these subjects. But I could not appear for the university examination in science, after studying at home, because science had a practical component that required a laboratory. So my ambition to become a doctor ended and the road to become a mathematician opened up, although I was not aware of it at that time. I liked mathematics because of its precision and because I was better at it than others.

Throughout my educational and professional career I had the strong support of my parents and elder brothers Lakhbir and

Bhupinder. I had the blessings of my grandfather who had called me “Vidya” noticing my inclination towards learning at an early age. He was all praise for persons who were good at arithmetic and his encouraging words were invaluable to me. My parents made considerable effort so that I could study at good colleges. I graduated with honours in mathematics from Government College for Women, Ludhiana, standing first in Panjab University in the B.A. and second in mathematics honours.

I joined Government College for Men, Ludhiana, for the M.A. in mathematics. All the teachers were men and some had the opinion that women cannot and should not do mathematics. I took it up as a challenge to prove them wrong. Professor K.R. Chaudhary, who was also the vice-principal of the college, was encouraging and helpful, and proud of my achievement when I stood first in Punjab University in the first year of M.A., getting 98% marks. He strongly advised me to go in for the Civil Services. But the pursuit of further studies in Mathematics was calling me. I had earlier met the distinguished mathematician Prof. R. P. Bambah, who advised me to pursue research. I joined the Department of Mathematics in August 1962 as a research fellow.

The department had an intensive program including basic courses and research seminars. The first few months were really hard. The vastness of mathematical literature and unsolved problems overwhelmed me. Adjusting to the hostel environment, trying to come up to the expectations of the faculty and interacting with other research students: all seemed too much for me. I thought that Chandigarh was a very unfriendly place. I started working on open problems and by the end of 1963 had obtained results considered enough for a thesis. I was later awarded Narasinga Rao gold medal for two papers published from my thesis in the Journal of Indian Mathematical Society.

In the meantime, Prof. Bambah decided to go to Ohio State University, Columbus. All his research students were offered fellowships there. My parents were very encouraging and agreed to my going to the U.S.A. even though some close friends and relatives advised against it. I finished my course requirements in a short span, getting all A grades and received my degree in Decem-

ber 1965. I was the youngest Ph.D. from OSU up to then!

After taking up brief teaching assignments at OSU and University of Wisconsin, I decided to return to India. Life in the States was definitely more comfortable and there were more opportunities, but I preferred to live in India. I married Jagjit Singh Gill in 1968. He was at the IARI, Delhi. A major problem that we faced was that we could not get jobs at the same place. We decided not to compromise our careers. Soon little Ramneek and Hardeepak arrived and the help of my parents and parents-in-law was invaluable in bringing them up. With the moral and physical support of our families, we were able to resolve all major and minor problems.

For several years I was the only woman on the faculty of our department. I always tried to do my best so that my colleagues did not feel that women contribute less. My colleagues were mostly very helpful and readily tried to make time table adjustments whenever needed. My research is in the geometry of numbers: packings and coverings, Diophantine approximations, non-homogeneous indefinite quadratic forms and view-obstruction problems. I collaborated with my colleagues R.P. Bambah, V.C. Dumir, Madhu Raka at PU and A.C.Woods from OSU. Our efforts over many years led to a proof of the long standing conjecture of Watson on non-homogeneous minima of quadratic forms. I have been elected fellow of the three major science Akademies of India and also a fellow of TWAS.

Most persons hold mathematics in awe. Meeting a woman mathematician shocks them and they start narrating how scared they were of maths in school. I used to feel very amused till I started noticing that even my children were developing fear of mathematics!

Circumstances just guided me to mathematics. An eminent mathematician was my research guide, I have had wonderful collaborators, many bright students, and a healthy work environment at Punjab University. Above all, I had an understanding and supportive family. I have always enjoyed discussing mathematical problems. The happiness one feels on solving a difficult problem is indescribable.



37

Science and the art of detection

Gaiti Hasan

When I think back on the reasons for my becoming an experimental research scientist in biology, I find many were accidents of fate. In our family it was taken for granted that girls studied and went on to a career. Marriage came along somewhere but was not considered an essential end-point to one's studies. My two elder sisters studied chemistry and physics, and both my parents spent most of their working lives teaching and working in a University. Growing up in this environment, the idea of becoming an academic seemed natural. The big question was which academic stream to join when I finished school. My own inclination was to pursue an undergraduate degree in physics; this desire was driven mainly by a good physics lady teacher at school. Luckily, this did not happen. My school in Aligarh did not have a mathematics teacher qualified to teach us higher secondary level maths; without maths no good university would admit one to an undergraduate degree in physics. The other available options were chemistry or biology and biology was already beginning to seem more interesting to me.

I joined a zoology honours course at Miranda House, Delhi University. All our teachers were women. They taught us with great

enthusiasm and tirelessly took us through the long experimental component. The course structure had its high and low points. The best part was the wide range of subjects taught. I spent a good bit of my time reading physiology, development, ecology and evolution in the college library. I realized that we were missing out on molecular biology and genetics – very little of either subject was taught in those days at the Bachelor's level. This was the reason why I decided to move for my Master's degree to the newly founded School of Life Sciences (SLS) at Jawaharlal Nehru University in New Delhi.

The M.Sc. course at SLS was again a mixed bag. But thanks to an inspirational teacher for molecular biology (H. K. Das) and a growing interest in genetics (egged on by P.C. Kesavan) I finally knew at the end of my M.Sc. that molecular genetics was the field I wanted to work in. During my Master's I spent two summer schools at T.I.F.R., Mumbai doing experimental molecular biology. But the mix of genetics and molecular biology that I hoped to work in didn't seem to exist in any lab that I knew of in India. Along with some of my friends I decided to start applying to universities in England – at that time the U.S. still seemed very far from home. While making my applications to U.K. universities I realized for the first time that belonging to a minority could lead to discrimination. What came as a bigger shock was that the discrimination came from a woman teacher! A lesson I have learned from this experience has been to consciously try and be supportive of other woman scientists, be they students or colleagues.

I finally went to a lab at Cambridge for a Ph.D., where I studied gene organisation. At Cambridge I understood what was meant by experimental rigor; from listening to seminars by some of the best biologists at that time I also learnt to think about biology as a whole. On completing my Ph.D. I took the unusual step of coming back to T.I.F.R., Mumbai for a post-doctoral position. I still wanted to work on an interesting biological problem that could be addressed using molecular genetics. T.I.F.R. had groups that offered the possibility of working on olfactory genes in *Drosophila* that no one else in the world was studying as yet. It was an exciting time when I worked at tracking a gene down to the mo-

lecular level – a bit like a detective novel! The molecular biology unit at T.I.F.R. was a very special place and the intellectual training in genetics that I received from Obaid Siddiqi's students, Kavita Arora and Veronica Rodrigues, has lasted my entire career.

After completing the molecular cloning of an olfactory gene I was thinking about how to use *Drosophila* molecular genetics to address more general problems in biology. I had just got married, my husband was going to work in Boston for his post-doc and I met up with Kalpana White who was visiting T.I.F.R. She was very helpful and advised me to write to Michael Rosbash at Brandeis which was in the Boston area. I wrote to Michael saying I wanted to look for the period gene in mammals. After six months when it became clear that this project was going nowhere in my hands, I decided to try something different – reverse genetics in *Drosophila*. Michael was most supportive and encouraging of this new project which was to look for the *Drosophila* receptor for inositol 1,4,5-trisphosphate (InsP₃). Since the gene had been recently cloned in the mouse, no one really understood the physiological context in which it functioned. I used the newly discovered method of PCR to clone the *Drosophila* gene in Brandeis and then brought the project back to my lab at the National Centre for Biological Sciences in Bangalore, of which I was a founder member while I was still at TIFR, Mumbai. It seemed an ideal project with which to start my own lab. We could do genetics to make mutants, we could do molecular biology with the mutants and finally we could use the mutants to look at cellular function, development and physiology.

My lab still works on this problem and we are now busy trying to relate InsP₃ receptor function in *Drosophila* with human diseases like diabetes and neuro-degeneration. The best part of working in science is the freedom to take on a problem that interests you intellectually. The tough part is balancing the long hours of work with raising a family. A supportive family is a must. And just when you think you have done both you realize there is another part to science – the networking required to stay visible nationally and internationally. Most existing networks are male-

dominated and women need to work harder and more systematically at entering these. Or no one will ever know about the wonderful scientific breakthroughs you may have achieved quietly in your lab!



38

The amazing world of life science

P Mohanty Hejmadi

I wonder if I had ever thought that I would be a scientist, explore the unknown, and work on living animals to decipher the mysteries locked in the non-descript simple egg! Born during pre-independence era, I grew up in the euphoria of post-independence. The world just opened up in the most unpredictable way! My father Shri Bhagabat Mohanty had relinquished a lucrative job as an engineer under the British Government, had a successful career as a contractor and financed the independence movement. My mother Shrimati Nisamoni Devi became a freedom fighter. Growing up in a house which became a hub of independence movement, I was exposed to the women who were breaking grounds in the most-unpredictable way.

Education in those days was more of a routine affair. As my father chose to build our house in a secluded place, I was homeschooled until roads came up to our house so that I could take a bus to Ravenshaw Girl's school. Going to a girl's school meant a life of leisure but being inculcated with a spirit of independence and a life without barriers meant a rather zig-zag career. I took music as optional subject in high school, and opted for science in college. Going to the majestic and co-ed-Ravenshaw

College was a big transition. The striking buildings, the quadrangle, the manicured lawns and seasonal flowers were overwhelming. The world of science was enchanting and doing experiments was a joy. Like most girls in science those days, I wanted to be a doctor but could not be admitted as I missed the mandatory age for entering and therefore, had to opt for B.Sc. instead. Being fascinated by animals, I took up Zoology honours and my life took a decisive turn. After B.Sc. I did not want to enter the Medical School. I went to Lucknow University for my masters which was both adventure and eye-opener.

I returned to Orissa after my M.Sc. and took up a teaching position in the newly opened M.Sc. classes in Utkal University. I was exposed to research through the few journals we were receiving for the library. While pursuing various avenues, I was offered the Barbour Fellowship of University of Michigan, along with a Fulbright travel grant. I joined University of Michigan Zoology department in the beautiful city of Ann Arbor.

After my education mainly on theoretical materials, developing manual dexterity in dissection from guinea pig to the lowly earthworm (one still does if one has to understand zoology all over the world in a restricted sense), mugging facts and figures of a variety of pickled animals from all over the world; learning by realistic experience in Michigan – fertilizing frog eggs, grafting live tissues to chicken eggs or crossing different strains of *Drosophila* to study genetics – was awesome. The experiments in physiology, cell biology and genetics charged with the euphoria of cracking of post-genetic code era; life science was gaining momentum. The miracle of fertilization, the unraveling of genetic programming in the nascent amphibians eggs starting with the lines of tension in cleavage, the complete division of egg and rearrangement of cells and appearance of different organs to make a tadpole and then the metamorphosis drew me to Developmental Biology. I completed my Ph.D. on the “Transfer of Maternal Serum Proteins and their Role in Development in the American Leopard Frog *Rana pipiens*”.

After my return to Utkal University, I built up a laboratory for research on amphibians and later endangered reptiles.

While pursuing super-regeneration in tadpoles under the influence of vitamin A (initially discovered by I.A. Niazi of Jaipur University,) we published our “Breakthrough” of transforming the tail to legs in amphibians known as homeotic transformation in *Nature* in January 1992. This drew international attention both to the phenomenon as well as to our laboratory.

Recognition has come in many forms, including the Padmashri in 1998: I was the first woman to be elected President of Indian Developmental Biologists, and was the first woman Vice-Chancellor of Orissa–Sambalpur University (1995-98). After retirement, I continue my study of science through memberships in various agencies and by writing on science.

Ultimately, science is a window of unlimited opportunities. Going to the lab is like an adventure everyday. The results of experiments, whether success or failure, enrich life like never before. Science is ultimately an art where life presents opportunities to feel and live it. Although I could have opted for a more glamorous career in pursuing dance (the art critic Charles Fabri wrote that I could have “name, fame and fortune”), I opted for science as it provided an opportunity where one can mould and nurture a career with a very private space. To me science opened up a world of unknown opportunities, seeing the world, interacting with many eminent scientists, artistes and policy makers – a charmed life which I will never regret.



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With no regrets

H Ila *nee* Bhatnagar

I was born in a middle-class educated Kayastha family from Mathura, U. P. In our family, girls were supposed to be highly educated, as well as to develop household skills. My father, the late Ramesh Chandra Bhatnagar (M.Sc., Physics, 1936, Allahabad) was the first inspiration in my life who sowed the seeds of perseverance and perfectionism in me.

I was the third sister in a family of five daughters and two sons and my father's aim was to educate his daughters just like his sons. At a time when there were not many career choices for women, I was encouraged to become a medical doctor.

After I passed high school in 1958 (from the Methodist Girls' High School, Moradabad, with distinctions) my father was transferred to Gorakhpur where I finished the intermediate in 1960 (from A. D. College), and the B.Sc. in 1962, from Gorakhpur University. Simple living and high thinking was our motto at home. My father expected us to top the class in every test and examination. Although, we did not need to work very hard (most of the other girls were studying to get a degree just as an ornament!), my father's expectations created an indirect pressure: I felt as if the world would collapse if I stood second in the class!

In 1961 I appeared for the pre-medical test for U.P. state and I topped the examination The first time a woman candidate had ever done so! However I was not destined to become a medical doctor – I joined King George Medical College, Lucknow, but returned home after a week to continue my B.Sc. at Gorakhpur University. When I look back, I am still not clear why I left medical college (surely it was not ragging!). May be I was afraid that I would have to study for several years: M.S. or M.D. after the five years of M.B.B.S. However, what an irony, as I am now in a profession studying whole life as a researcher and teacher (which I enjoy most). Anyhow, even today when I am at the end of my career, I do not regret this decision.

In 1962, my father was transferred to Kanpur. I finished my M.Sc. in Chemistry in 1964 from D.A.V. College, Kanpur. The best thing which occurred in my life was admission into the Ph.D. programme in chemistry at I.I.T. Kanpur. I was just being packed off to Allahabad University, my father's dream university, to pursue a Ph.D. programme with a C.S.I.R. fellowship. However, a sudden interview call from I.I.T. Kanpur changed everything. Facing stalwarts like Profs. C. N. R. Rao, P.T. Narasimhan, M. V. George and M. S. Muthana, I was really nervous, and at first, they were not willing to admit me since I had not studied mathematics at the bachelor's level. I was admitted on Prof. Rao's suggestion that I be allowed to take an extra 'Mathematics for Chemists' course.

After that, there was no going back. Most of the young faculty at I.I.T., including Profs. Rao, Narasimhan, George, Ranganathan and Chakravorty, were highly enthusiastic about building not only our career, but theirs as well, and it is these teachers who created in me a genuine interest and love for chemistry. Those were the happiest days of my life filled with challenges and dreams of becoming another 'Madame Curie'!

I was the first woman to get a Ph.D. from I.I.T. Kanpur graduating in 1968 and a short post-doctoral assignment at Purdue University, I joined the Central Drug Research Institute, Lucknow as Research Scientist in 1970.

I married Junjappa in 1971, another turning point in my

life. Such south-north marriages were not common at that time; it was a conscious decision on my part as a marriage of two professionals. Organic chemistry has remained the biggest binding force between us throughout our lives! We started our careers as a husband-wife team. Ila- Junjappa is better known in chemistry circles than Ila or Junjappa!

Time passed very fast and we never realized it, since we were deeply engrossed in research and publishing papers. Year 1976–77 brought another turning point in our life when due to professional reasons, both of us decided to join North Eastern Hill University, Shillong, a decision which we never regretted. My husband first went to Shillong as founder Head of Department. It was then a bare forest with no research or science culture. However this did not diminish our spirit and after three to four years of hard work, we built one of the best chemistry departments of the country with a state of the art laboratory and library and instrumentation facilities. Those were the most productive and challenging research years (1980–1990) with publication of several breakthrough papers in heterocyclic chemistry. Despite several geographical disadvantages of Shillong, its scenic beauty and people enriched our lives.

After spending more than 18 years in Shillong (1977–1995), I returned to I.I.T. Kanpur, my alma mater, as professor, spending my last eleven wonderful professional years there. A few awards and recognition came to me, though late in life and after many disappointments. However, at the end of the day, what matters most is whether we enjoyed our journey or not and my answer is yes. I enjoyed every bit of my life, my passion for research and teaching organic chemistry, ‘our husband-wife research team’ our daughter, our friends, my travels abroad and above all, hundreds of our students, who enriched our life.

I should especially thank our sixty Ph.D. students who have made us sustain research and are doing extremely well in their professional lives both in India and abroad. It is like having sixty children spread out all over the world, since we always had a familial relationship with our Ph.D. students.

What helped me to sustain my career was first of all my

passion for organic chemistry, then hard work, perseverance, and aiming for excellence, perfection and creativity in every aspect of my life, the lessons taught by my father. My husband was highly cooperative in grooming me as an independent and professional woman.

Would I do anything differently if I had to do again? My answer is no, since I believe in Dalai Lama's teaching that 'under any circumstances, try to do your best, so that when you look back, you do not have any regrets'.

And I do not have any regrets in my life.



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A journey of discovery

Chanda Jog

For as long as I can remember, I have been fascinated by nature and puzzled about its various features – from mountains, to rains, to the regularity with which the stars appeared to complete their revolution around us. I had the good fortune of living at the foot of the Sahyadri hills in a small town called Kalwe in Maharashtra for four years, from the age of twelve to sixteen. I was surrounded by nature in all its glory, from the morning dew on the grass, the cascading waterfalls in the monsoon, to fantastic animals like chameleons, salamanders and even an occasional snake trooping through our house. To me all these were interesting phenomena to puzzle over. I have been extremely fortunate in having parents who instilled and encouraged in me a sense of independence and curiosity about all things around. They taught me that knowledge does not come only from books or in a ready-to-swallow form.

The two subjects which most interested me at that time were geometry and physics. I remember spending long hours engrossed in the geometry riders assigned to me by my mother. The thrill of finally figuring out the construction and solving a problem by pure logic was my first experience in research. It also taught me, as I later realized, the value of persistence as well as the

confidence and deep pleasure that solving a problem can give you.

At an earlier age, I remember accompanying my father who was then an electrical engineer with the Ahmedabad Electricity Company, and being shown various kinds of lights and their different properties. Science and engineering were a part of life, to be approached with a sense of fun. Concepts which I now recognize as “sample selection” and “trying a different approach if the first fails”, were lessons I learnt at home from my father. Later, when I was in the eleventh standard, my sister, who had just joined the Bhabha Atomic Research Centre (BARC). training school as a scientist, introduced me to books by George Gamow, including his stimulating book *Mr. Tomkins in Wonderland*, and I got hooked on physics and astrophysics in particular. With such a strong home background it never occurred to me to doubt if I could pursue science despite being a girl. Even later, being mostly self-driven has helped me treat any obstacle in my career as a temporary problem.

Doing a Ph.D. in the United States, brought new opportunities and encouraged an openness to things, and most importantly the necessity of steady, dedicated, hard work for a scientist. There, I also met Alope Jain, who is now my husband, and who was a student at Stony Brook at the same time. Alope has been a pillar of strength during all these years, urging me to give my very best to research, standing by me at all stages of my career, and acting as a sounding board for my many research ideas. Now research in astrophysics has become a way of life, almost an obsession. I consider myself lucky to be a professional scientist – thoroughly enjoying what I do, and getting paid to do it.

In school, I had a very strong interest in literature, especially poetry related to nature, and in classical music. Music remains essential for my day-to-day life. Had our home atmosphere been stronger in literature or music, it is possible I might have chosen to pursue them.

The home atmosphere is extremely important in shaping a child's thinking. We have tried to encourage our twin daughters, Abha and Deepa, to pursue whatever subject they like with joy and dedication, and devote their full energies to it. Alope's practi-

cal, no-nonsense approach has made them strong and determined with a can-do attitude, which is very important. It has been a real privilege to have this class of two young enthusiasts right at home! Guiding research students is also a highly educative process – both about the science we do together and also the psychological insights one gets from it.

The main problem I faced after returning to India was that when I was younger and it mattered the most, no one took any notice of me or gave me active encouragement by showing me the ropes, or making me a part of the science network. This benign neglect meant delay for me personally, and seen from a larger perspective, was also a loss of research opportunity for the community. This is a common problem for any budding scientist and especially for a woman scientist. Surprisingly, the same is true of women in the US and in Europe, as seen repeatedly in the discussions in a forum like the “Women in Physics”. An even bigger problem has been working in India in a field like astrophysics that is highly dynamic and interactive and literally exploding in many subfields worldwide.

It has often been a lonely struggle and it need not be. For my part, I have tried to help younger people – my own students and post-doctoral fellows, as well as others here and in Europe, by showing them the ropes and the possibilities, mentoring them whenever I can. Apart from helping an individual, I think this also will help stop the waste of trained, scientific talent and ensure a more robust scientific community.

I am happy I have made some impact in the areas of galactic dynamics and interstellar molecular clouds on the world scene. I have explored and initiated work in areas of coupled star-gas instabilities and vertical-disk dynamics in galaxies, triggering of starbursts by shock compression of gas, lopsided galaxies, and the dynamics of interacting galaxies. Keeping in touch with observations has been crucial in the way I have phrased problems.

In retrospect, if I had to do it all over again – I am at the same time wistful and relieved at not having to go through it all again – I would do some things differently. I would ask for help more readily. I would try to travel more to international scientific

meetings, and establish contact with others in the field at an early stage so that many interesting collaborative projects could be done. The latter has become easier not just financially but also because of the ease of channels such as email. The way science is done has changed dramatically over the last decade, and yet there is no alternative to personal meetings with other scientists in order to really trigger new ideas.

The one thing which has kept me going is the overriding curiosity to know what makes things work – whether galaxies, their dynamics, or star formation. I enjoy the challenge and thrill of looking at new problems. The sense of mystery as I think about these problems is the deepest pleasure of doing science. After this mulling period when the ideas are mostly a picture in the mind, comes the phase of formulating the problem – which is the hard part – then solving it, most often numerically before comparing the results with the observations.

I can also see how exciting other fields in science are, for example the biological field at the level of how a cell functions, or at the other end, the cognitive aspects. It is spooky to think of the mind thinking about the mind and so on without closure. The complexity of the biological sciences, and the different logic used in these compared to the physical systems, are fascinating.

Time and capability limits scope to dabble in or even obtain enough information to truly appreciate technical questions and advances in other fields of science. Being at a broad-based institution like Indian Institute of Science (IISc) has been a boon in this respect. Over the years, I have been able to learn about other fields and also build warm friendships.

I am extremely fortunate to be able to live a life of research in science, and to be able to work on challenging, new research problems, so that each day is a journey of discovery!



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Encouraging students to ask right questions

Sangeeta N Kale

It is normally said that teachers lay the foundation for the kind of person one becomes. At the college and university level, I was very fortunate to have such people around. Since childhood I was fond of experimental science. I developed a habit of trying to do simple experiments either at home or in the school. I also loved to write down small diary of my curiosities in science a random set of notes, from “Black Holes”, “Teleportation”, and “evolution of mankind” to “walk on moon”!!

After my graduation (science) and post-graduation (Electronics-Science) from Pune University, I started my Ph.D. in Materials-Science in parallel with teaching at one of the top colleges in India, Fergusson College. I then went to University of Maryland, as a post-doctoral research fellow for duration of about two years. I have been quite fortunate to deal with various aspects of academics, right from formal teaching and handling research projects to counseling of students, formulation of university syllabi and doing administrative duties. I have been formally teaching basic Material-Science and Electronics courses. It was during this journey of teaching and research that I realized a gap

in formal education of city colleges where there was compartmentalization of education and research.

I feel that education is a continuous learning process. This is accomplished by gaining knowledge which has already been unleashed, and experimenting to know deeper and better. I have always thought that an ideal education system is one which strives to give both conventional science education, as well as being a platform for students to satisfy their curiosity and do experimental and theoretical research.

As a faculty in Fergusson College, along with formal teaching and laboratory assignments, I attempted to give my students more than what the curriculum could offer. This included extra talks by in-house and invited experts in various fields, from basic sciences to technological current-edge advancements. Since my area of research has been material-science in general and nanomaterials in particular, I established a base in this area in the institute and developed a modest research laboratory in the year 2003 with funds from Indian Space Research Organization (ISRO), University Grants Commission (UGC)-Department of Atomic Energy (DAE) and Department of Science and Technology (DST). This was an extremely difficult period for me, but we published many articles from (visiting scientist) at Fergusson College. I also got recognition as an Associate Member International Center for Theoretical Physics (ICTP), Italy.

Our research group has published many research contributions since 2003, which are published in peer-reviewed international journals like Physical Review Letters, Applied Physics Letters, Physical Review-B, IEEE Transaction on Magnetism, Journal of Applied Physics, Journal of Biomedical Technology, Applied Surface Science and Nanotechnology, among various others. My students have attended many international and national conferences to present their work. Students and young staff members work in my group, which are not only from Fergusson College, but also from colleges in and around Pune.

Especially for women professionals, family support is extremely important. The support of my husband, Narendra and most importantly, my mother-in-law, has been extremely

significant. My in-laws have unique qualities and provide constant encouragement, freedom and appreciation of my academic endeavors. There have been crucial times when I had to leave my two years old daughter (Nikita) with my in-laws to go for doing my post-doctoral studies. Only family support ensured that I could take this opportunity, which was one of the landmarks in my academic career.

A strong desire to pursue research has taught me that with immense hard work and sincere efforts, everything is possible. I have been very passionate about good quality research. Connection to research makes the process of education intrinsically dynamic. While it is essential for faculty in educational institutes to keep abreast of new knowledge through research, a proper balance needs to be struck between commitments and teaching as well. This is particularly true when under-graduate students are involved. I dream of a vibrant, creative, knowledge-based environment, which will not only benefit the students from career point of view, but will also enhance the institutional growth. It is this motivation, which has kept me going and hence also involving young students in my work.

Scientific research has its origins in a very fundamental human character – curiosity. It is very important though, to ask the right question. And I believe that it is one's job (as a faculty and researcher) to make students ask right kind of questions!!



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My journey in science

V Kalpagam

It all started in our own house. My father did his M.Sc. by Research in Physics from Madras University and then joined as a lecturer in the then-famous Nizam College in Hyderabad which was affiliated to Madras University. He took us to his laboratory during our formative years. He used to inspire us always by explaining the scientific significance of all the things that we came across in our daily life. We had plenty of popular books to read at home. Quite a few colleagues of his used to visit our house and we children had good interaction with them and their children, most of whom were our classmates in school. I was very fortunate to have supportive parents and good advisers from the beginning. Our maternal grandfather was an engineer and one of my maternal uncles joined IIT Kharagpur for B.Tech the year it started.

I studied in a missionary school. The teachers always spoke of the importance of education and the importance of standing on one's own legs. Some of these teachers were my father's students at their graduation studies. They used to speak very highly of him and advised me to achieve that status. At that time I never thought that I would follow his footsteps, but I had the zeal to do well and top in the class. There was always a keen competition between me and my friend who happened to be the maternal aunt of the famous cricketer V. V. S. Laxman. This competition contin-

ued till our Intermediate (present 12th std) stage after which we parted ways as she went for medicine.

The Principal of our school, Miss De Lima was loved by one and all. During our Ethics class when she quoted sometimes from scriptures she made it a point to quote from Hindu Epics, Bible, Koran etc. The poet queen or the Nightingale of India Sarojini Naidu, visited our school often, being a friend of the principal and was indeed a role model for us. Her special connection to Nizam college also caused her to take more interest in me due to the fact that my father was teaching in Nizam college.

I was lucky to be introduced to Prof. Bhagavantam at an early age as he and my father were research colleagues. I was also lucky to listen to lectures delivered by Sir C. V. Raman and a number of other scientists who came to Nizam college from time to time. May be all this had an influence on me though at that time I didn't have any clear ideas.

After my H.S.C. (10th std) results when I had to join college, I took up PCM (Physics, Chemistry and Mathematics) in Inter and B.Sc, not having any interest in biology and not wanting to do medicine. I chose to do my M.Sc. in Physics at Osmania University. When I passed my M.Sc. my father's maternal uncle, a Barrister at Chennai was keen that I should take up the Civil Services Exams as a cousin of my father was in the IPS. However I had no interest in that field and did not pursue that line.

S.Bhagavantam was then the Vice-Chancellor of the Osmania University. I met him and requested him to take me as his student for research. Within a year of my joining him he came to Bangalore as the Director of I.I.Sc. Thus my journey to Bangalore started with him. I had done a little work on Light Scattering Studies of Polymer Solutions at Osmania. At I.I.Sc. the light scattering instrument was just then procured by the Inorganic and Physical Chemistry Department. Hence Prof. Bhagavantam advised me to join the IPC department.

In the IPC department I had to take a number of courses in Physical and Inorganic chemistry and do quite a bit of laboratory work to familiarize myself with the subject and techniques involved. Finally after a few years of struggle when one submits

the thesis one feels that one has achieved something in life. At this stage, I have to thank all my kith and kin, teachers, colleagues, friends and foes who assisted me constantly to reach this end. From there the next part of one's journey starts - a job. I was lucky to get a position in the same department. in I.I.Sc. Thus I could continue to be in the field of science till the day of my retirement.

Even as I was settling down in my job, I was selected under UNDP to visit M.I.T., USA, to study about the emerging subject 'Materials Science' as the Institute was planning to introduce this subject as a core course for the Engineering students. I was attached to Prof. Smakula of the Electrical Engineering Department. Apart from teaching this course for the freshers in the department, he was working on crystal structures. Any way, I was free to move around, attend some classes in Materials Sciences and frame the syllabus. This subject was taught in different Engineering Departments by staff with different backgrounds. They gave a lot of importance to practical work. Back home, we had to be satisfied with just giving lectures in one semester.

I also had a very enjoyable meeting with Prof. Vikram Sarabhai. I saw his name plate on one of the doors in the same floor where I was working. He was visiting MIT now and then, it seems. On the third day of my work there, he himself called on me and enquired about my welfare, work and so on. He was delighted to know that I was from I.I.Sc. He gave me a vivid description of his experiences at I.I. Sc., Physics Labs at Ahmedabad, starting of ISRO and so on, apart from talks about arts and other related subjects.

After my return from the US apart from taking the materials science classes, I continued with my research work on light scattering studies of polymer solutions. One by one students joined to do their Ph.D. Slowly we drifted from polymers to copolymers. We also dabbled with the mechanical properties of these materials trying to understand how they vary from a polymer to copolymer. During those days getting chemicals was a herculean task as the budget was meagre and everything had to be imported. It was a difficult task to make the students understand to share the poverty!! Any way we continued trying to collaborate with Central

Leather Research Institute (CLRI), Madras. They were working on graft copolymers.

A lot of my work focussed on understanding how polymer degradation occurs. The idea was to make biodegradable copolymers so that they can be used for biomedical purposes. Copolymers are obtained by grafting synthetic polymers taking natural polymers which degrade, as a backbone. If a medicine could be enclosed in a biodegradable capsule then the medicine would be slowly released at a particular site and thus would avoid the need of taking the medicine a number of times a day. We did a little preliminary work on this aspect in collaboration with Sri Chitra Tirunal Medical Institute at Trivandrum. About a dozen students got their Ph.D. working on these problems and we could publish quite a few research papers in International Journals.

I had the pleasure of framing and setting up the polymer science lab at Sri Jayachamarajendra Institute, Mysore when they started B.E. in Polymers. I was a member of their Board of Studies and an examiner. I had a lot of interaction with CLRI Madras; Madras University, I.I.T. Delhi, Madras and Kanpur as an examiner for Ph.D. theses, viva voce, paper setting for Materials Science and Polymer Science. I also gave a number of popular lectures for Institution of Engineers, HAL, ITI, NAL and so on, apart from participating in Materials Science and Polymer Science conferences by way of presenting papers, chairing sessions etc. I was also a member of different professional societies including American Chemical Society.

It has been a satisfying journey. During this I have had company and ample support of my husband Prof. V S R Rao, who was also a professional scientist and a professor at the Indian Institute of Science. There were of course issues involved in balancing family and profession, but nothing that could not be handled.



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Combating indoor air pollution

Priyadarshini Karve

A majority of Indians reside in rural areas. In spite of growing urbanization, this state of affairs will continue for at least a few decades. The nation cannot attain the so-called ‘superpower’ status unless special efforts are taken to strengthen the rural economy. The spine of the rural economy is the rural woman, who is increasingly playing the dual role of the home maker as well as the bread winner.

My work contributes to easing the life of rural women to some extent. For as long as I remember, I have always wanted to make a career in science. It was not a surprising ambition. My father is a prolifically talented and successful scientist. Belonging to a family of several generations of social reformers and rationalists, I grew up without the burden of gender discrimination. Even the society at large expected me to do something out of the ordinary. These circumstances have certainly made life easy for me!

I neither enjoyed nor abhorred studies in my school and college days – generally managed to do just enough to stay near the top of the class, year after year. However, the fact that a physical phenomenon can be fully explained with a mathematical ex-

pression particularly fascinated me a lot, and I decided to major in Physics. In my final year of B.Sc. Physics, the curriculum required me to do a research project. At that time my father was Deputy Director of the Centre for Application of Science and Technology for Rural Development (CASTFORD) in Pune. For my project, I worked on optimizing a mixture of sawdust and soil to make compacted fuel for an improved cook stove at CASTFORD. The results of the study were unexpected and interesting, but more importantly, I got fascinated with the scientific challenge of using a wide variety of fuels (from cow dung cakes to logs) with a variety of chemical compositions (different moisture content, ash content, etc.) and physical attributes (different densities, shapes, sizes, etc.) and extracting the same 'quality' of cooking energy day in and day out.

I went on to pursue M.Sc. Physics, in University of Pune. This was the first time I really 'learned' and enjoyed studying. I took 'Energy Studies' as one of my elective subjects in final year of M.Sc., hoping that it would explore the broad canvas of present and possible future science for producing and using various forms of energy. However, the course was primarily focused on describing solar energy technologies. Nevertheless, it gave me another opportunity to do a project in CASTFORD. This time I worked on design optimization of a sawdust fueled stove. And this has now evolved into a commercial product!

By this time I was totally convinced that I wanted to work more in this field. But there did not appear to be any possibility of getting a Ph.D. by working on something as primitive and 'trivial' as providing clean cooking energy to a rural kitchen. Rather than working in a mediocre research group in apparently related areas like solar energy, I chose to work with an internationally reputed research group working in frontier areas of physics. I worked on diamond coatings at the Department of Physics at University of Pune (I 'created' diamonds in my laboratory every day!).

Although I immensely enjoyed the work that I did for my Ph.D., I was back to biomass energy once I had earned my doctorate. My father and his colleagues had by then evolved CASTFORD into Appropriate Rural Technology Institute (ARTI), and wanted

projects for the new organisation. I came up with the idea of converting sugarcane trash into charcoal, and submitted a project proposal to Department of Science and Technology's Young Scientist Scheme. Through this project, we developed an oven and retort type charring kiln and a briquetting process for converting any type of loose biomass into char briquettes. We also developed a highly energy efficient system for using the char briquettes for steam cooking. This cooking device is now quite popular in both rural and urban Maharashtra, and is also attracting people from other parts of India as well as other parts of the world. Towards the end of my Ph.D. work, while netsurfing I stumbled across an e-discussion group on stoves. Through the group discussions, I took the initiative to organize an International Conference on Biomass-based Fuels and Cooking Systems through ARTI. One of the conference delegates, impressed by our technology of converting agricultural waste into charcoal, suggested that we apply for the Ashden Award for Renewable Energy. We did it very tentatively, and ended up winning the award in 2002. Since then, ARTI has moved from strength to strength.

Throughout this period I was awakening to three facts. One, indoor air pollution in the kitchen was a serious and yet the most neglected hardship faced by rural women of the developing world. Two, replacing biomass energy with fossil or other energy sources in rural kitchens was either impractical or not happening fast enough. And three, developing better ways of extracting clean cooking energy from biomass fuels was not enough; concentrated effort was needed to take the innovations from the laboratory to rural kitchens in a sustainable manner. Through support from the Shell Foundation from 2003 to 2005, ARTI built a network of 10 grassroots-level NGOs and through them more than 100 energy enterprises came into existence. Through these enterprises, about 75,000 rural households in Maharashtra purchased clean cooking devices by paying the market price.

Meanwhile my own not-so-inspiring experience of school and undergraduate level teaching and the subsequent enjoyment of learning during post graduate and doctoral research period had generated several ideas about science teaching. After getting Ph.D.,

I grabbed two opportunities for putting the ideas in practice. Firstly, I joined hands with a group bringing out a Marathi bimonthly, 'Shaikshanik Sandarbh' (educational reference) targeted at school level science teachers. Through this periodical we try to motivate and assist teachers to make science learning an enjoyable experience for the students. I also taught for five years Applied Physics in an Engineering college, trying out my ideas in theory as well as laboratory courses.

Today I am engaged in the challenging task of fine tuning and scaling up the concept of rural energy enterprises. Being drawn into addressing the socioeconomic issues related to mitigation of indoor air pollution, has to some extent distanced me from scientific research, but it has not brought it to a complete halt. Interacting with entrepreneurs and rural women has helped in pinpointing several subtle issues requiring scientific solutions – for example, importance of ease of manufacturability and transport in developing designs for cooking devices or importance of understanding the varying energy requirements of cooking tasks in developing new fuels and cooking devices. I believe that although my scientific work over the years may be relatively less in quantity as well as quality than many other professional scientists, it will have a much more direct impact on the life of people. That is what matters the most to me.



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A mathematician in every life...

S K Khanduja

I was born in a small village near Ambala. My father was a freedom fighter. My mother though not formally educated, was extremely hard working and took keen interest in the study of her children. She was a pillar of strength for me till the end of her life in 2001. Though I was not educated with the goal of a career, yet my parents, my brothers and my sisters always motivated me to excel in studies. I was forced to learn all the skills that an ideal wife or mother needs, for which I now feel thankful to my family. Arya Kanya Maha Vidyala, the high school, where I was educated, had some extraordinary teachers. Two of them Mrs. Maya and Mrs. Maina who had lost their husbands in the partition riots in 1947, are worth mentioning. For them teaching was a mission, and their house was open to students all the time. Our school Principal, Mrs. Roop Ahluwalia, had high expectations, that I would bring laurels to school, I did so in the higher secondary examination in 1968.

My interest in Mathematics was due to an excellent college teacher Miss Gulshan Arora. I decided to pursue Mathematics as far as I could, and I joined the Department of

Mathematics Punjab University (PU), Chandigarh as a post graduate student in 1971. I was fortunate to be taught by stalwarts like Professors R.P. Bambah and I.S. Luthar.

Prof. Bambah, a well known number theorist, inspired me in research and Prof. I.S. Luthar, my Ph.D. supervisor, was a teacher par excellence. After submitting my thesis in an algebraic number theory in 1976, I started teaching in the same department. My marriage in 1979 and the arrival of my two sons, in 1980 and 1984 did hinder research work for a few years. But once my children were in school, with the support of my family, especially my mother, and with inspiration from my senior colleagues, I resumed research and working as professor in the same department.

My Ph.D. students have been a great source of strength for me, motivating me to think of new and interesting problems and then to tackle them jointly or alone. This has led to over 50 publications in international journals. It has given me great satisfaction that my work is internationally recognized among specialists in the area. I wish I could do Mathematics till the last day of my life and if there is another life after death, then again I would like to be a mathematician.



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The accidental astronomer

Pushpa Khare

I was born and brought up in Indore, Madhya Pradesh. Most middle-class Maharashtrian families prioritized education for their children, and my parents were no different. However, I was very lucky to have parents who did not distinguish between boys and girls when it came to education. Of course, education was not very expensive then. There were excellent highly subsidized municipal schools which most middle class students attended. They had quite good facilities, well-equipped, spacious laboratories, good classrooms and huge playgrounds. We had some very good teachers, and learning in general was an enjoyable experience.

My father, a medical doctor inspired me to take up physics at the college level. He was impressed by the Department of Atomic Energy that had been set up and he wanted me to join it to do research on atomic energy. Physics also interested me very much (along with mathematics), so I went for post-graduation in physics.

The only college in Indore which offered M.Sc. physics course had a good academic atmosphere. Some of the teachers were highly enthusiastic and inspired the students. There was healthy competition among us, and most of us did well at the national level entrance exams conducted by various research

institutes. I was lucky enough to get selected by Bhabha Atomic Research Centre (BARC), Tata Institute of Fundamental Research (TIFR) and Indian Institute of Technology (IIT) Kanpur. In spite of my early ambition to join the atomic energy establishment, I did not join BARC as it seemed too restrictive, TIFR did not have hostel facilities for girl students, so I ended up joining IIT Kanpur. I shifted to TIFR in a few months' time after satisfactory arrangements were made for accommodation.

My choosing astronomy was somewhat accidental. Astronomy was not very popular then, and I was almost unaware of the subject until I joined TIFR. A variety of factors combined to make my Ph.D. a stressful, lengthy process, but I persisted and finally finished in about seven years time. I should mention one thing here. At no time during my entire student career was I ever discouraged from taking up physics or from pursuing a research career, because of my gender. This is in stark contrast to what a budding British woman astronomer told me in the 1980s. She and her fellow girl students were actually discouraged by their teachers from choosing physics or maths, as these subjects were considered beyond woman's capabilities. I must say, we in India are much less prejudiced in this respect. An American graduate student, aspiring to become an astronomer, confided in the 1990s, that in the US, doing physics and maths was considered unwomanly, and girls who took up these subjects found it hard to have boyfriends!

By the time I finished my Ph.D., I was married and followed my husband to Bhubaneswar, where he was a scientist in the Institute of Physics. Thereafter, my struggles started. I had no prospects of getting a job in Bhubaneswar or its vicinity, as astronomy was done at very few places in India then. I did not seriously consider the option of staying as far away as Hyderabad or Mumbai.

Prof. Deo of the Department of Physics at Utkal University who had a keen interest in astronomy encouraged me to frequent the department. To have some sort of affiliation, I actually registered again as a research scholar. This paid dividends when Judith Perry, an astronomer from the Max Planck Institute, visited the department to give some lectures. My interaction with her during her short of few days ended up in my getting a

postdoctoral fellowship at Munich. By the time all the paperwork was completed, I had a three-month-old son. On my request, my mother-in-law immediately agreed to accompany me to Munich with my son. At Munich I really enjoyed doing astronomy, and I am tremendously grateful to Prof. Deo and to Perry for their help when it was crucial for my survival as a physicist.

After returning from Munich, I joined Utkal University again, this time as a pool officer. Eventually I got a lectureship in the same department and am now a professor there. Continuing research in astronomy in Utkal University was not easy. There were no books or journals, and there was nobody to talk to (I was, and still am, the only astronomer in the entire state of Orissa!). I was about to switch fields, when I had to accompany my husband to Chicago for a year and got a chance to work with Don York of the University of Chicago. I have been collaborating with York ever since, for the past 20 years.

The establishment of Inter-University Centre for Astronomy and Astrophysics (IUCAA) in 1988 was a great boon for me. I started visiting IUCAA regularly. The excellent facilities there and the encouragement that I received from IUCAA members boosted my research career. I was also fortunate in getting an excellent student, and together we did some good work. With the internet becoming available, it has now become much easier to pursue astronomy even in a remote place like Orissa.

Finally, I should mention the support and encouragement that I have received from my husband all along. He strongly believes in man-woman equality and has always helped me with housework and in bringing up our children. It is only due to his encouragement that I have continued my research. I have been extremely lucky.

With the modern facilities like big telescopes, satellite-based observatories and huge computational power along with advanced image-processing software, astronomy has become a very interesting subject. A lot of important discoveries are being made and often make newspaper headlines. It is amazing how with only a passive study of the light coming from the distant heavenly objects at our disposal, we have learnt so much about the universe. Hats off to the human spirit.!



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Walking through clouds and rains

Medha Khole

My father, a man of ethics, paid the highest regard to values and education through his entire life. He had studied Science up to graduation and was a post-graduate in Law, the subject closest to his heart, which he studied with particular reference to human psychology. He was the chief mentor in my life. He never possessed any traditional ideas about the lives of his daughters, and encouraged me and my sister to acquire the highest education in our respective fields. He cultivated in me the urge to learn and enjoy the pleasure of learning. I was born and brought up in a Hindu Middle-class family in Pune. I studied in Marathi medium which is my mother tongue and when I passed the tenth class examination, I had a great inclination to study literature. But, I scored 88% marks in the examination and all my school friends had decided to study science so I too took admission for science at Fergusson College, which is one of the most reputed colleges in India. In the next two years, I developed very strong aptitude for science and I continued for B.Sc. Course in Fergusson College. It was during these three years period that I started liking Physics very much, particularly, Quantum Mechanics. My professors were sincere and taught us well. I

enjoyed the practicals. Though initially I used to be quite nervous, but I learnt the joy of discovering theory taught in class or read in books, coming alive in practical classes and the principles learnt being actually visible through experiments. After completion of B.Sc. in Physics from the University of Pune with a high academic record, I pursued the studies for M.Sc. in Physics at the University of Pune. My father's encouragement stimulated me for taking up this course.

After acquiring a First Class M.Sc. degree in Physics in 1989, I appeared for state and national civil services examinations. My primary interest was to serve society and I felt that the civil services would be the best way to do this. I enjoyed studying for these examinations, and was selected twice for Group A Gazetted Officer through the state civil examination. I worked for a brief period in the Income Tax Department. There was no connection to science in this job, but I enjoyed there also. Meanwhile, I was selected as a Group A Gazetted Officer by Union Public Service Commission and I opted for the India Meteorological Department. I underwent training in meteorology for one year and was introduced to the fascinating research world of meteorological science.

Meteorology is truly an interdisciplinary science involving Physics, Mathematics, Statistics, Geography, Environmental Science and allied fields. I got to understand the applied nature of the science of Meteorology and its direct bearing on all of us through the impact of weather and climate. After training, I worked as a weather forecaster in the Area Cyclone Warning Centre, Mumbai for about a year and a half and gained experience in various aspects of operational weather forecasting, including cyclone warning. Thereafter I was posted at the Meteorological Office at Pune in 1994 and worked in the Research Unit for over 8 years. During this tenure, I used to teach various subjects in Meteorology to trainees at the Regional Meteorological Training Centre of World Meteorological Organization (WMO) at Pune. This helped me understand basic concepts of Meteorology and provided me an opportunity to be in constant touch with the subject. I started working on the variability of Indian monsoons, and published my

research in national and international journals. I also presented some of the research results in various seminars, at national as well as international levels. I completed my doctoral thesis based on the variability of Indian monsoons and its linkage with the phenomenon of El Nino Southern Oscillation (ENSO) and submitted it to University of Pune, and was awarded the Ph.D. degree by University of Pune in the year 2001.

I have continued my research in the field of Monsoon Variability, ENSO, Natural Hazards and allied areas of Meteorology. At present, I work as the Director in charge of Weather Central, Pune. This centre issues weather forecasts for 36 meteorological subdivisions of India, twice daily, for all the 365 days of the year. The work of weather forecasting is extremely challenging. In a tropical country like India, the unpredictability of the weather is very high as the governing forces are different than those in the higher latitude countries. In view of the issues of Climate Change, Global Warming and related issues, public awareness in the area of Meteorology has grown tremendously in recent years. At present there are many misconceptions about the science of weather and climate in the society, owing primarily to inadequate information about the subject. From both these points of view, there is wide scope for outreach activities. I work in this area as well, delivering public lectures, and by writing articles.

I have not come across any particular difficulties while pursuing my career in science. I developed a strong liking for science and research during my college days; this widened my outlook and has developed in me logical and rational thinking and an objective outlook. A career in Science has also had a positive impact on my personality. Through sustained research interests and effort I was able to get the doctorate degree 11 years after the completion of M.Sc. course.

Had I not opted for education in science, I might have taken up the study of Marathi literature. My life, as it has turned out, is different, to some extent, from the one what might have been expected for some of my background and circumstances. I find that literature – a subject dear to me from my school days – provides me the strength to face difficult moments and offers me

perspective on my choices. I feel satisfied with my career so far and can see many goals to be achieved in the future. A scientific career has been very rewarding experience and I feel that I would not have liked to do anything else.



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Curiosity, ambition and foolhardiness

Vinod Krishan

My early years were spent with my grandparents in a care free village setting. Growing up with no thoughts of the future has its own merits, and a part of my foolhardiness, I suspect, is a result of that. By my fourth grade, however, thanks to my mother's efforts, I was restored back to Delhi to live with my parents.

One day, in my physics class, we were taught the circuitry of an electric bell. On reaching home, I sneaked into the store room and greedily recovered a rusty electric bell from the junk box. With a thumping heart, I wired the connections shown in my physics book and turned the switch on! To my utter dismay not only did I not hear any ringing, but the whole switchboard rotated (was it the J cross B force?) and the house plunged into total darkness. When my father summoned me, my honest confession brought an unexpected smile to his face, and from that moment onwards I continued to remain foolhardy, a trait perhaps essential for a budding scientist! My father never, allowed me to be complacent and urged me to pursue my career. I owe to him whatever little I have achieved and a lot that I have enjoyed.

It was a period of uninterrupted fun and games until I

completed my M.Sc. in physics from the University of Delhi. This still remains a crucial time in an Indian girl's life as it generally heralds a transition from a single to a coupled state! I was no exception!

After I got my Ph.D. from the University of Tennessee in less than three years, the very blessing of a scientist-lifemate became a formidable obstacle: finding two jobs in a single physics department or even in a single city appeared to be nearly impossible anywhere. After several years of hardship, sweat and tears, penance and perseverance we overcame the jinx.

With a position at the Indian Institute of Astrophysics, an invitation to participate in the 1979 Autumn College in Plasma Physics at the ICTP, Trieste was the biggest break in my professional life. Since then there hasn't been an unaccounted moment. Being in the world of learning at the ICTP, I regained my curiosity, and, more important, my foolhardiness which propelled me to be so bold as to go against the tide and suggest that turbulence instead of dark matter can explain many of the astronomical puzzles such as the flat rotation curves of galaxies. These proposals have caused some curiosity in the community. I attribute it entirely to the spirit of fresh enquiry that the environs of the ICTP induces and inculcates in its inmates.

Equally important has been the inspiring and enthusing company of some of the most distinguished scientists from all over the world in almost all disciplines of physics. I developed interests in socio-geo-ecology issues, meeting fellow scientists from different countries and established some collaborations. The ICTP kindled in me a desire to visit countries as varied as Brazil and Japan. Working in astronomy and astrophysics provided me the whole universe. Bangalore's intellectual and cultural heritage has contributed in no mean manner to my growth as a conscientious scientist.

Careers come naturally to men; women have to make a conscious choice and plan their lives as to when and what type of a professional to marry, when to have children and how much to participate in family matters and when to say no. This is if one wants to live life to the full and especially to fill it with the joys of

motherhood. It would possibly be sensible for a woman scientist to marry an academician with a tenured job and with at least a seniority of five years in order to minimize the professional competitiveness. Family support is the absolute prerequisite!



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Creating something out of nothing

Yamuna Krishnan

I was privileged to be born into a family where education was highly valued and emphasized regardless of gender. Both my paternal grandparents were renowned obstetricians and gynaecologists, while my maternal grandfather was the editor of a well-known newspaper, *Deccan Herald*, for about twenty years. Born to an architect father and a literary mother, I had the fortune to grow up in an environment where both science and the arts were cherished. As a child I received the best possible education, though neither of my parents took an active interest in making me stick my nose into my textbooks. My mother used to read to me before I could speak a single sentence (or so she tells me) and spent more money than she could afford on books, which inculcated in me a love for reading. I am told that as a child I had an amazing memory, but this certainly was not reserved for school work. I was never the topper in class and was content to remain in the top twenty per-cent, just enough to not perturb my parents overly.

Curiously, it was during the preparation of one of my mother's several books that I met an unforgettable older friend of my parents, S. Krishnaswamy, who was then Vice Chancellor of Madurai Kamaraj University. He kindled an interest in me to do

experiments at home – small experiments, mostly repeating things I had read in my text books. How a siphon works, how one can grow small sea creatures in brine. And then later, along with my sister, I started to conduct experiments myself - making soap from oil, making invisible ink, growing sugar and salt crystals – in short, anything possible with the resources of my mother's kitchen and father's garden. My beloved all-seeing mother quietly encouraged this by getting me several books; later, a microscope and even a small chemical lab (in collaboration with my father) equipped with a few harmless salts that didn't do much, but created in me a zest for experimenting. This was complemented by the chemistry practical sessions at school. I would quickly finish the designated experiment and then spend hours pottering around with solutions that were not on the specified list, much to the horror of my classmates and an indulgent lab assistant who took a shine to me and turned a blind eye.

When the time came to choose my stream after high school, despite having a penchant for creative writing and painting, I chose science, because of my love for experimenting. I wonder whether I would have chosen arts if there had been a vibrant extra-curricular programme for the arts at school. When I entered college, I remember wanting to do architecture, but ended up settling for chemistry as a compromise. It was probably the best bend-in-the-road that ever happened to me; it turned out that what seemed Hebrew to most was dazzlingly clear to me. I understood the language of molecules and reactions as if I had known it all along. Suddenly I was the best student in class.

Leaving behind the wonderfully supportive set of teachers at Women's Christian College, after my bachelor's I enrolled for an Integrated Ph.D. programme in Chemical Sciences at the Indian Institute of Science, Bangalore. I did my doctoral thesis in a lab, where my supervisor, Santanu Bhattacharya, offered me complete freedom to experiment. My early research was on the self-assembly of small molecules to form various kinds of supramolecular aggregates such as liposomes, liquid crystals and organogels. In collaboration with Sandhya Visweswariah at IISc, I developed a liposomal reagent that was highly effective in

bringing about DNA transfection. My association with her was brief – just six months – but her influence on my thinking still remains.

I also developed the first molecule that could selectively gelate the oil phase from a mixture of water and oil. This work received wide acclaim from peers in the field due to its potential application in oil-spill clean-ups as well as in separation technology. Throughout, the Chairman of the Department, S. Chandrasekaran, who was also the coordinator of the Integrated Ph.D. programme, gave me much advice and support, and continues still to do so. I must mention two people without whose support I would never have survived the early years of my Ph.D., when despite the drudgery there was a drought of results. These were my uncle, Ravi Menon, a well-read and patient banker-philosopher, and Arindam Ghosh, a brilliant physicist and understanding partner, whom I later went on to marry, whose unstinted support allowed me to reach my potential as a researcher.

While in India, I studied the effects of modifying small molecules that cluster in large numbers, resulting in a change in the property of the clustered structure. Towards the end of my tenure, I became fascinated by proteins and nucleic acids that were more complex, where information is hidden in a single, long string that folds up in space to form a functional entity, where the three-dimensional shape is crucial to function. Later, with Shankar Balasubramanian at the chemistry department in Cambridge, UK, I studied the assembly of an unusual form of DNA that was four-stranded, called the G-quadruplex. Shankar was an excellent mentor; he gave me freedom to experiment, and discussions with him left me thinking long after. He actively encouraged me to apply for various fellowships, which I would never have thought of doing on my own. The chairman of the department, Jeremy Sanders, whom I had encountered in many discussions, provided me with staunch support in all my subsequent academic endeavours. I was elected to various fellowships such as the 1851 Fellowship and the Fellowship of Wolfson College, both of which brought me in close proximity to several wonderful minds. When I felt the call to return to India, these senior colleagues despite their own

opinions, realized this was something I needed to do, and advised me in their own special ways; much of this advice has stayed with me to date.

Having worked all this while in chemistry-based environs, and realizing that I was slowly gravitating towards biology, I chose to jump into the deep end, and position myself in a biology-centred institute. In 2005, I set up my own lab at the National Centre for Biological Sciences, T.I.F.R. in Bangalore, in the best environment I could ask for. I was aware that my chemical language and perceptions would be quite incongruous, not dissimilar to the plight of a stranger in a foreign land. But realizing that I was by nature eager to try new things and learn from new experiences by putting my best foot forward, I took the plunge. Looking back, what I did almost qualified as foolhardy. Fortunately, a few senior colleagues took an active interest in mentoring my transition from my post-doctoral view of chemical biology, to a more full-bodied way of thinking. At the moment, my lab is looking at how one can use designed nucleic-acid assemblies to interrogate cellular processes by functioning as intelligent probes and signal transducers.

My fascination with nucleic acids has taken me from chemistry to materials to chemical biology. My driving force has always been to create, out of a set of meaningless, individual components, a collective entity with new and unusual functions. And so here I am, still experimenting, by the grace of the many people who have loved me enough to let me go.



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Woman! Work like an ant, act like a man, but remain a woman!

Sulabha K Kulkarni

To become a scientist for a woman means adopting quite a different but challenging way of life! It requires extreme hard work to be successful on all the fronts—professional, personal, and social. In order to be even an acceptable scientist she has to work much more than her male colleagues. This, however, is not enough in a male dominated society. Actually, she has to work like an ant, act like a man and stay like a woman! A woman has a lot of inner strength but she has to recognize it. Additionally, a woman scientist requires a sustained support and understanding from her husband, children and relatives, as a scientist she has to get truly engrossed in research. It is a twenty-four hours job! I consider myself to be fortunate enough to get all that without any reservations.

Today, while looking back, I can say that I could successfully take on the challenges in my career because of my urge for learning and perseverance, the seeds of which were sown in my childhood. I always liked to tackle the difficult problems and

enjoyed working hard to solve them successfully.

The school I attended in Wai (in Maharashtra,) was good, however, the emphasis was on languages and social sciences. Physical sciences were taught in a dull and uninspiring way, but I had developed a love for mathematics. (Thanks to the teachers like Shri W.L. Bapat and Shri P.K. Gune, who inspired me.) So I entered Fergusson college in Pune with the idea of pursuing mathematics. Later, I chose Physics, as it involves substantial amount of mathematics.

The real motivation to pursue science came from M. R. Bhiday (then head of the Physics Department in Pune University) who encouraged us to 'do science yourself'. The number of girl students taking higher education and particularly Physics was very small at that time. Surprisingly, there was only one lady faculty member, who used to discourage us from doing research!

As a part of my Ph. D. work I designed and fabricated an automatic scanning X-ray spectrometer. In 1972 it was not easy to do this at our place! I began setting up a demountable X-ray tube, a high voltage power supply for it and electronics for scanning spectrometer, right from painting a circuit board, etching and assembling various components! In the current context it might not be a great thing. But to see the X-ray generator working and the spectrometer actually recording X-ray fine structure like that in the literature was a wonderful experience for me. It indeed gave me the confidence, which helped me in future to work on some extremely sophisticated and state-of-the-art instruments.

Prof. Bhiday and my research supervisor Prof. A. S. Nigavekar encouraged me to do postdoctoral work in Germany. This was an opportunity I had not imagined. My husband did not want me to go away for a long time but I somehow could convince him, emphasizing my desire to enter a new, emerging area of surface science. I told him how the postdoc experience would help me in setting up a new laboratory in our department.

In Prof. Menzel's laboratory at the Technical University of Munich, in 1977, in a big group of about 25 students and postdocs there was not a single woman student, faculty or post doc. Even today, there are very few women working in the field of science

and even fewer make it to the top.

I returned to Pune University in 1978 as a faculty member. I spent a lot of time setting up the surface science laboratory. It was not easy. In the absence of e-mails and even fax, it was difficult to communicate. This was the most crucial period of my career and it took unexpectedly long to get the laboratory started. We eventually started publishing in international journals of high reputation. There are ups and downs, sometimes things work well, sometimes nothing works in spite of your efforts, but one should never give up.

The atmosphere in my department has been good. Like everywhere there are elements of jealousy and rivalry but they have not hampered my progress enormously! The progressive atmosphere set up by Prof. Bhiday is still maintained. And this ambience has attracted many girl students to join the department and also my group for research. I have also encouraged them to make a career in science.

Creativity and challenge in science have always enthralled me. To my satisfaction, I could build a reasonably well equipped laboratory in Surface and Materials Science. People who do not know me well, might wonder how I could do it! Do not I have a family? Indeed a woman has to spend enough time with her family, especially when her children are young. But if she plans the work properly, I think, there is enough time for everything.

Not all has been rosy in my research career. There were many occasions when I was given challenging responsibilities and I completed them successfully. But at the time of rewards male colleagues were preferred! I wonder if this was the price of being a woman scientist. The saying goes, 'that's how the cookie crumbles'. Ideally, there should be no such thing as gender in science and I have tried my best to work in that spirit. From my experience, I can say that women can work efficiently and creatively. They can do equally well, even better than men. If women are given fewer opportunities, they should not feel discouraged. If one door closes, another opens. They should continue to work, because only continuous hard work in the proper direction brings rewards and satisfaction.



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No choice but to learn

Anuradha Lohia

One glowing blue dot in an all-black background. It may divide to become two, or just stay one, or even decide to die. Its a wondrous sight – the nucleus of *Entamoeba histolytica* going through its cycle of replication and division.

Entamoeba histolytica is a protozoa that has the potential to cause dysentery and liver abscesses in humans. Apart from causing disease, this parasite has many other fascinating attributes that excite biologists. In evolutionary terms, it represents a ‘primitive’ eukaryote; it has a simple two-stage life cycle and is not ‘free-living’. Although the development of drugs such as metronidazole has drastically reduced the incidence of deaths due to *Entamoeba* infection, the biology of the parasite is not well elucidated. For the past eighteen years I have been working on the molecular mechanisms that regulate cell division in this organism.

When this often stressful, sometimes frustrating, but always exciting journey in science began I endured many uncertainties in choosing this as a life path. I was born into a business family of the Marwari community, where a career path for women was unheard of when I was young. My mother, herself a pathbreaker, decided to study applied psychology and follow a career in education.

ing special children with mental retardation. This decision of hers changed my life even before I was born. I was encouraged to pursue studies and fine arts with equal vigour. As a result, of my own interest and will, I was equally engaged in studying human physiology and performing classical dance.

When I stepped into a Ph.D. programme to study the biochemistry of the *Vibrio cholerae* cell surface, it began to dawn on me that it would not be easy to carry on both professions in tandem. However, I was unwilling to let go of either profession even after the birth of my daughter in 1981. Family and friends suggested that my success in classical dance should, for obvious reasons, result in my choosing it as a career. I was indecisive, because even though I was good at Kuchipudi and enjoyed performing, I felt I was not given the creative freedom to bring my own personality to my dance.

To add to this confusion, I was failing miserably in my research at (IICB) Kolkata. Experimental results were open-ended, funding was limited and more importantly, my ideas were very hazy. I thought I understood less than my colleagues and was constantly plagued by doubts of my own scientific ability. The less I understood, the greater the challenge and, consequently, the greater my desire to excel in research. Unable to give up either profession, I continued to dance and carry on my research (along with bringing up a little daughter) until I published two papers in international journals and finished my Ph.D.

Prof. Bimal Bachhawat, Director of (IICB) in 1985, would often treat graduate students to tea and samosas and share our concerns, when he found us working on weekends. During several such sessions, he ensured that I thought of going abroad for post-doctoral training. He understood my difficulties with family pressures but did not accept them and I ended up writing a few applications for post-doctoral positions. Before, I knew it, I was offered two positions, and then I faced the most difficult time with my family. Additionally, I was torn between my daughter's welfare and my desire to continue research. It was all finally resolved but my troubles did not end. Two years at New York University, spent almost entirely in the lab just blew away when another group pub-

lished my results before I could write my paper. I had to return; I could not stay away from my daughter any longer, knowing that I faced failure as a scientist.

However, I got a second chance with Prof. B.B. Biswas at Bose Institute to set up a lab studying the biology of *Entamoeba histolytica*. I started with isolating DNA replication origins from *E.histolytica* and published my first paper in record time – and have never looked back.

In the mid-eighties, the common goal was to develop vaccines against pathogenic organisms and therefore research was targeted to the identification of useful antigens. However, my foray in trying to tame genetic manipulation of *Plasmodium falciparum* during my tenure as a postdoctoral fellow, showed that we needed to understand DNA replication, cell division and regulation of gene expression before a successful vaccine would be designed. When I set up my lab at Bose Institute, I focused on studying cell-cycle regulation in *E.histolytica* specifically, because it appeared to lack any checkpoint control mechanisms.

Friends and well-wishers often chided me, saying that basic biology should be studied in traditional “model” systems. But in my desire to learn, I did just the opposite. In the absence of commercially available tools and reagents we learnt to design our own. It is now possible that in the near future we will be able to unravel a mystery: how does the amoeba survive without tight checkpoint control? That may well be a cornerstone in identifying how it survives in the human host. Regardless, what we have found while researching the biology of this tiny pathogen has inspired me with awe at the wonder that is nature.

The journey is difficult – obtaining grants, publishing papers, ensuing the success of Ph.D students and making sense of the data we generate. I keep questioning the relevance of what I am doing in the larger scheme of things, but ultimately, the biology of *E.histolytica* beckons tantalizingly and I keep chasing my research ideas. *E.histolytica*, has taught me to be aware of my limitations and yet strive beyond my abilities. It is far more difficult to do experimental science in India than in developed countries and therefore to publish, but a sense of contribution to infrastructure

development and successful manpower training sustains me in moments of self-doubt.

Halfway down the road, I have no regrets that I ultimately gave up dance when I went away to the US. Arguably, I had several lucky breaks that ensured a career in science, but I think even if I had not got the opportunity at Bose Institute, I would have developed my skills in a different aspect of science.

I knew so little that I had no choice but to learn. And I continue to learn, watching the amoebae under a microscope, their nuclei marked with a fluorescent dye as they grow and divide. And sometimes don't divide.



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A born dreamer

Chitra Mandal

I began my journey at the age of four in a small village called Khamerbaria in West Bengal. My mother sent me to the only school nearby, where the sole teacher had to look after all the children from classes one to four. The teacher did not appreciate the idea of taking care of a four-year-old girl, as that was odd in those days, especially in rural areas. The teacher, being very clever, agreed to admit me only if somebody could take care of me in school. My grandmother came to my rescue. I was very happy – I was the only student whose grandmother was allowed in.

I always followed my mother around with a book. I loved to study and I would read while staying close to my mother. Therefore, almost all my books were spotted with *haldi*. “Do you cook your books?”, my teacher used to tease. My mother inspired and encouraged me to believe that education was the only way to fulfil one’s dreams in life. My father used to come home once a week on Saturday nights. It was difficult for me to be awake at that late hour and to read by a small kerosene lamp. But that was my only opportunity to impress my father with my progress in studies. He was keen to keep track of my education, and I passed class four with impressive marks.

My father worked for the government. Although a brilliant student, financial constraints prevented him from pursuing

higher education. My mother devoted her entire life to her five children. Her devotion, intelligence, and kindness were always focused on us. However, she was very adamant about our education. Having not received formal education, she used to tell us that education was the only real thing in life, which would open many doors for us. The family's dream was to see us receiving higher education. At home, reading story books, newspapers, school books and novels was always encouraged. I used to read anything printed that I could get my hands on. Reading was, and still is, my real joy. We were always encouraged to do anything related to books.

My mother protected me from child marriage, which was very common in the village. After I completed the fourth grade, my mother took a very bold decision – to move from that remote village to a nearby town for my further education.

I was admitted to a missionary school in Bankura, West Bengal. Ever since I was a child, I wanted to be a doctor. After finishing high school, despite my mother's strongest support, other family members opposed my entering Medical College. However, my dream was fulfilled when the family's attitude changed for my sister. After completing eleventh grade, I was admitted to Bankura Christian College with Chemistry Honours and thoroughly enjoyed the subject. Our teachers were very good. Being the only girl, I used to get a lot of attention from them. I am a born dreamer.

During college, I read about Madam Curie, and wanted to spend my life like her – immersed in science. My interest in science, I think, came from reading books. I used to think scientists are like God and could cure any disease if they wanted to. I dreamt of becoming a scientist to solve the mysteries of the culprits responsible for diseases. I wanted to learn the chemistry of diseases.

After graduation, I left my hometown, as there was no university there. Again there was a storm in the family regarding my higher education. But by this time I also had a strong and confident voice and convinced them that this was my strongest wish. I got admission for my master degree in Chemistry, at Burdwan University. I was lucky to have a group of dedicated teachers who kept alive my passion for science. I loved to spend time in

the practical classes; this gave me immense pleasure.

My journey took me farther and farther away from home, to the Indian Institute of Science (I.I.Sc.), Bangalore. The entrance exam was very tough, and the mental pressure was enormous. In those days, going from Bankura to Bangalore, more than 3500 km away, entailed a four-day journey by bus and two nights and three days by train!

Getting admission in I.I.Sc. was the most important turning point in my life. Bangalore was a completely new world for me! This was my first opportunity to mix with students from other provinces, whose languages were so different! It seemed that the whole world was opened to me. The library used to remain open seven days a week. When I got my own key to the organic chemistry department, I was thrilled. Now I could spend as much time as I wanted in the laboratory.

In those days, in India blending the physical sciences and the biological sciences was very rare. The opportunities at I.I.Sc. aroused my enthusiasm to learn not only chemistry but also biology. Accordingly, I was keen to pursue research in immunology during my post-doctorate training. As an organic chemist; I thought if I could utter the words 'antigen-antibody' I would be an immunologist! I was determined to join a top-class molecular immunologist, though I did not know much about immunology. Fortunately, I was selected to join the laboratory of Prof. Fred Karush at the University of Pennsylvania. My experiences in molecular immunology opened a much wider door for me to study cell surface molecules, proteins, glycoproteins and their alteration in diseased conditions. During this time, lots of exciting scientific events were happening. People were developing monoclonal antibodies using Nobel Prize winning technology invented by Kohler and Milstein. I too was keen to learn this technique. I never stopped dreaming of learning new things and conducting new experiments.

I always wanted to pursue my career in India and I joined the Indian Institute of Chemical Biology (I.I.C.B.) as a young scientist. Now I wanted to blend my knowledge of immunology with chemistry and was ready to switch gears. I wanted to combine basic research with applied aspects, which was extremely un-

common in those days in India. Prof. B.K. Bachhawat, director, inspired me to continue such research. Even today, my ongoing research is in this direction, related to diseases.

I still love to dream and I think being a scientist is the best profession, as you are paid to fulfil your dreams. This is the profession where you can have new and unexpected experiences through hard work and you cherish extraordinary moments which cannot be realized in a job with big salary. I had an overwhelming satisfaction when I realized that my simple diagnostic kit would help many poor unfortunate patients suffering from kala-azar and infected with a life-threatening parasite. When I inform the parents of children suffering from acute lymphoblastic leukemia that there are no cancer cells left as minimal residues of the disease, I feel satisfied.

Finally, I believe, with passion and sincerity it is possible to fulfil one's dream despite difficulties, which women face. However, I was extremely lucky to have a full support from my life partner, a brilliant scientist, who had a passion for science. He is the one who inspired me to go further in my education than I had ever dreamt. He is my collaborator throughout my research career. The true aim of a scientist is to understand the world. I used to tell stories of my laboratory to my little son. Whether he understood or not, he felt as if he was a part of it. I am happy I did that, and he never felt dissociated from his mother's dream. A successful engineer, still he is with me. The support from my husband and son give me the strength, power and courage to proceed in my scientific work.

I urge young women researchers never to give up hope and never to forget to dream but always be open to problems in life, research and elsewhere. I sincerely believe that Indian women have a lot of power to fulfil their ambitions. As a woman, I have had to face many difficulties. But I never gave up. The more I struggled, the greater was my desire to do my work. In the end, nothing could stop me. My fight went on.

I cannot remember a time when I did not want to go to my lab – it is my dream place and I never feel bored. In view of my experience, I am sure if I had to do it all over again, I would do the same thing. I do not think I have been disappointed with myself and I have never regretted the choices I made.



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Hard work and perseverance lead to success

Kusum Marathe

I was born in 1924 in Mumbai and joined school when I was seven years old. In those days very few girls went to school and they used to get married early. My father, Mr. Shankar Gangla, though a building contractor, was deeply interested in education. My elder sister and I studied in St. Columba High School which had a beautiful campus, green lawns and big playing courts. It gave us good education. In high school, our science teacher Mr. Rane used to actually demonstrate chemistry experiments in class, which was one reason why I developed an interest in science.

I wanted to become a doctor, but when I passed intermediate, I was under age for admission to medical college. Hence I joined the Royal Institute of Science, Mumbai for BSc with botany as the principal subject and chemistry as the subsidiary. When I passed BSc with distinction and stood first in botany, I was awarded a Fellowship. So I dropped the idea of becoming a doctor and enrolled for MSc to do research in botany under the guidance of Prof. Ella Gonzalves. Mrs. Gonzalves, an algologist, assigned a re-

search project to me ecological, and taxonomic studies of soil algae of Maharashtra. For this I collected composite soil samples from various fields, especially paddy. I made liquid and solid cultures and recorded the algae appearing in these cultures. I also studied the effect of fertilizers on these algae and published papers based on these experiments. These were the first of their kind and were often quoted.

When my research was nearing completion, Prof. Gonzalves was transferred to Karnatak College, Dharwar. I moved there to complete the thesis and got a demonstrator's job in the same college, starting my teaching career. I submitted my thesis to Bombay University and received my degree in 1948. I was later appointed as Assistant Lecturer in Botany and in 1950, I married Dr. V. B. Marathe, Lecturer in Zoology in the same college.

When Dharwar was allotted to Karnataka state, both of us were transferred to Mumbai. First I was posted at Ismail Yusuf College, Jogeshwari, where there were no research facilities; and in 1958 to the Royal Institute of Science (RIS). I wanted to start research but I had two sons. My second child was prematurely born. Besides, there was no recognized Ph.D. guide for algae.

However, I collected soil samples, made cultures and continued my research in the spare time I got between my lectures and practicals. Meanwhile, Dr V.R. Dnyansagar, who had moved to RIS as Professor and head of the botany department, agreed to register me as his Ph. D. student. I continued the same project I had undertaken in M. Sc and submitted my Ph. D. thesis in 1968, twenty years after the M. Sc.

In 1970, I was selected by MPSC as Associate Professor of botany and transferred to the Institute of Science, Nagpur, where my husband was already transferred as Associate Professor of zoology. He started a fresh water fisheries section in the zoology department. After joining the Institute, I started a special subject 'Algae' for MSc at Nagpur University. A few years later, I was promoted as Professor, and in 1980, I became Acting Director of the Institute of Science, Nagpur till 1981. I retired in 1982.

Although I could guide research only at a late stage, I have had seven Ph. D. students who worked on various research projects

such as metabolic products of algae, drainage water algae, nitrogen-fixing algae in paddy fields, effects of algal extracts on the germination of seeds and seedling growth. I have published over forty research papers. I did not get much time for research due to my teaching and administrative responsibilities. I sincerely feel that more research on algae will reveal many more algal species which can be used as food, manure, and as a source of oil, as we had found considerable oil in a new *Zygnema* species.

Starting as a demonstrator in 1947, I retired as Professor in a premier research institute. I have been able to achieve this because of hard work and perseverance. I am happy with my career both as a teacher and as a scientist.



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An unusual route to science

Minnie M Mathan

As a child, I was inspired by the devoted service to humanity and innovative surgical skills of my father, a doctor. I was determined to follow in his footsteps and be a surgeon. How did I become a Fellow and a Senior Scientist of the Indian National Science Academy? It is this unusual journey that I want to share with you. Pursuit of knowledge and academic excellence were major driving forces during my school years. My boarding school, where all the teaching was in the vernacular, instilled in me a sense of discipline and an enquiring mind. I got admission to the Christian Medical College in Vellore through an all-India competitive selection. I loved my training and the interaction with patients and enjoyed the challenges of my postings, especially in surgery.

After graduation and marriage to a classmate, I decided to continue working at Christian Medical College, where I hoped to do further training in surgery. But my surgical teachers discouraged me, saying the career was difficult for a woman (it was the 1960's!). At this time I got an opportunity to work in pathology and to my pleasant surprise I found that there were many challenges in the laboratory. Finding answers to them gave ad-

equate fulfillment to my enquiring mind, so I decided to be trained as a pathologist.

At the end of my training the department put me in charge of setting up a newly acquired electron microscope, and opened up the world of sub-cellular structure in tissues to me. For one who was familiar with tissues by light microscopy at magnifications of up to 1000 times, using the electron microscope at magnifications approaching 200,000 was a fascinating and uncharted world. I felt that the sub-cellular details revealed by the electron microscope would answer many questions of structure-function relationships. That was where I wanted to work. Ultrastructural pathology was a new field in India in 1967 and it was a challenge to train myself.

In 1970 I got an opportunity to work with Prof. Jerry Trier, a leading expert on gastrointestinal mucosal ultrastructure at Boston University. I was the only woman among twenty-four Fellows in the department! Those eighteen months honed my skills and taught me the value of hard work, meticulous precision, perfect quality and logical thinking, all of which became second nature to me. In 1971 my paper, selected for the Plenary Session of the American Gastroenterology Association, was the only one presented by a woman that year, a situation that has changed dramatically now. The work I did on the epithelio-mesenchymal interactions in the developing murine intestine is still cited.

Back at Vellore while working in diagnostic pathology, I chose gastrointestinal ultrastructural studies as my research area with the newly established Department of Gastrointestinal Sciences. I was able to publish my first paper on the ultrastructure of the small intestinal lining (mucosa) in healthy controls and patients with Tropical Sprue, a malabsorption syndrome, in one of the leading medical journals, *Gastroenterology*. I was excited and challenged to do better when this paper was judged the best paper in biomedical sciences published from India between 1972 and 1976. As the first gastrointestinal ultrastructural pathologist in India, it was exciting to work with a multidisciplinary team in the new department to unravel structure-function relationships in several gastrointestinal diseases with the electron microscope.

In 1973 Ian Holmes from Melbourne and Tom Flewett from Birmingham discovered the rota virus as a common cause of winter diarrhoea in infants, using direct electron microscopy of suitably prepared faecal samples. With their help I established the methodology at Vellore and showed that the rota virus was a significant causative agent of infantile diarrhoea in different parts of India. Our group became pioneers working to solve this important public health problem of our country. The World Health Organisation recognized my contributions and invited me to serve on their Steering Group on Viral Diarrhoeas. This gave me many insights into early studies of viral diarrhoeas of humans. The Vellore Christian Medical College appointed me to be their first Career Research Chair in 1981, allowing me more time for research. I obtained my Ph.D. in 1983, was elected to the Fellowship of the Royal College of Pathologists in 1996, and the Indian National Science Academy in 1998.

How did I become a scientist? I used the opportunities that were available and found positive aspects in whatever I did. I was fortunate that a field became available that was relatively new in India and that I realized its potential. The nurturing atmosphere of the Christian Medical College was very important in that they encouraged everybody to pursue and develop their dreams. A critical factor was the constant support and encouragement of my husband, who established and developed the Department of Gastrointestinal Sciences. The active cooperation and encouragement of the multidisciplinary team with which I worked and the ready availability of funds to support our research from the Wellcome Trust in U.K. were very important. Four decades later, the situation in India has changed and research grants are available on a competitive basis for good research ideas but in the 1960's it was a different story. I can honestly say that I have never felt discriminated because I was a woman. In all professional settings I was a peer among peers.

Fifty-two years ago when I started as a medical student my ambition was to become a surgeon. From that to what I am now is an unusual journey. My inherent need to know what was behind the apparent face of disease was what really made me a

researcher. Circumstances place different and difficult choices before you. My temperamental inclination to find the best way forward in any situation helped me travel to where I am. The two major turning points were my realisation that the laboratory contributes immensely to the welfare of the patient and my embracing the field of sub-cellular pathology where I could be a pioneer. It has been an exciting journey that continues. One last word. We unfortunately live in a globalized world and not a global village, and the temptation to move to greener pastures is strong. There are many challenges in our country in science and public health and I believe we have the opportunity to work on them, contribute and find satisfaction, if we look positively at things and go forward in quest of knowledge.



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The will to excel

Asha Mathur

My major work, spanning the last three decades, consists of in-depth studies of different aspects of Japanese encephalitis (JE) – its epidemiology, transplacental transmission, persistence, immune mechanism and chemotactic cascade, along with the creation of multidisciplinary state-of-the-art facilities in the field of medical virology at King George's Medical College, Lucknow, the aim of which is to provide diagnostic and investigative assistance for a wide spectrum of viral diseases.

I was born in 1938 to an accomplished family of Uttar Pradesh (UP), the second daughter of Jagdish Narain an eminent engineer. He introduced a number of innovative construction technologies in hydraulic engineering and was popularly known as the “walking encyclopedia”. My mother, Bindeshwari was a talented artist and a zealous reader. When patches of leucoderma began to appear on my face during my teenage years, my classmates and friends started avoiding me as there was much social stigma associated with it at that time. Though an enthusiastic and devoted student I stopped going to school, which resulted in depression and a severe inferiority complex. With support and encouragement from my parents, however, an indomitable will to excel awakened in me. After a break of two years I successfully completed my

schooling. I was inspired by my grandfather, one of the first Indian civil surgeons, and my uncle, a leading eye surgeon, to study medicine, and joined the Agra Medical College, from where I completed my MBBS degree. Subsequently, I joined King George's Medical College, Lucknow, where I earned the Doctor of Medicine (MD) degree, in Pathology and Microbiology, and was awarded a gold medal.

I accepted a faculty position in Microbiology at King George's Medical College and started teaching undergraduate and post-graduate medical students, as well as initiating research programmes in virology. I worked in various capacities at my Alma Mater for more than thirty years. Besides teaching, I also initiated research programmes based on scientific and humanitarian concerns. During my tenure, my colleagues and I brought the Department of Virology at King George's Medical College to another level.

In 1971, early in my career, I was awarded a World Health Organization (WHO) Fellowship to work on respiratory viruses at the Common Cold Unit in Salisbury, England, where I worked with the well-known virologists, Dr D.A.J. Tyrrell and Sir John Andrews. They motivated me towards basic research in viruses, which was still at a nascent stage in India.

The sternest test of my medical skills, knowledge of viruses, and of my perseverance came in 1978 when an unknown epidemic swept across the districts of eastern UP. The high mortality rate of this epidemic, especially amongst children, affected me deeply, and I resolved to crack this mystery killer. My team and I made a number of visits to the affected area, and worked hard to identify the cause of the epidemic. We successfully isolated and identified the Japanese encephalitis (JE) virus as the causative organism, and soon after developed a quick immunofluorescent technique for the early diagnosis of JE in patients. This was a turning point in my career.

Several questions baffled me about the epidemiology of JE. Delving into these questions led to the startling discovery that a JE viral infection during pregnancy could be transmitted to the foetus, resulting in abortion and foetal abnormality. This was a

completely new phenomenon, and led us to identify a series of mechanisms to explain the persistence, latency and reactivation of the JE virus in humans as well as in experimental animals. This work on JE captured international attention, and I was invited to present the results in London in 1980, and later at a number of international congresses on virology.

Around that time, an extensive discussion with a eminent immunologist Prof. C. A. Mims, London, UK led me to start work on molecular biology and to study the host response to JE. My post-graduate researchers and I realized that in response to JE infection, the immune cells of the body function through a regulated network of a unique chemokine which inhibits replication of the virus. This regulated network may be the reason why less than one percent of JV-infected patients actually develop encephalitis. Between 1992 and 2003, our work on cytokines received global recognition. This corpus of work was possible only because of a great team that included, over the years, fifteen Ph.D students. I have now retired from the faculty of KG Medical College, Lucknow, but continue to work as an emeritus medical scientist and still enjoy exploring new areas of research in the field of medical virology. Currently, I am working on dental fluorosis and the role of calcium at the Saraswati Dental and Medical College in Lucknow.

Over 190 original research papers have been widely cited in various monographs and textbooks. I have been conferred the First Senior National Women Bioscientist Award by Dept. of Biotechnology in 1999. I was also awarded the prestigious Om Prakash Bhasin Research Award in 1994, Indian Council of Medical Research Awards in 1983, 1987, 1996 and Medical Council of India awards in 1984 and 2004. I have been conferred the fellowships of the Indian National Science Academy, Indian Academy of Sciences, National Academy of Medical Sciences, National Academy of Sciences (Allahabad), the Third World Academy of Sciences and the British Royal College of Pathologists in 1987. My work has been included as the Pathfinder in the National Science Centre, New Delhi.

I have myriad interests which are as varied as fine arts (like

embroidery and painting), kathak dance and travel. I have been very fortunate to have had a galaxy of wonderful people around me – my students, friends, and especially my family including my nieces and nephews – who have made my accomplishments all the more rewarding and fulfilling. Society has given me so much unconditionally which has made me all the more generous and humble.



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A blessing in disguise

Anuradha Misra

I grew up in Faizabad, Uttar Pradesh, in a large family of ten children. My father, a doctor by profession, gave priority to higher education for children above all other matters. My mother, although highly intelligent and well-informed, could not study beyond high school. She made sure that her daughters received as good an education as her sons. Further, to educate herself, she kept reading books. This instilled in me a love for reading. However, coming from traditional orthodox Brahmin families, both my parents did not consider it necessary for a girl to think of a career. While all my six elder brothers chose science and mathematics as their subjects, my elder sister opted for humanities. There was slight resistance when I declared in class nine that I would opt for science, but they relented as by then it was considered quite natural for a good student to opt for science.

I chose science only because I loved mathematics and there was no option available to take maths with any other subject. I had to shift to an ordinary Government Girls' College to pursue science, but my maths teacher Mrs Vichitratarata Srivastava for the next two years was simply outstanding. An excellent and devoted teacher often changes the course of his or her students' lives. I enjoyed geometry so much that I was always looking for books

with challenging problems. In eleventh standard, I developed a liking for physics too.

I did very well in class twelve and my parents' initial aversion to my taking up science was replaced by feelings of pride and admiration. As Faizabad is a small town, I had to leave home to join the University of Allahabad as all my elder brothers and sister had done. It was a two-year B.Sc. (pass) course and I opted for Physics, Mathematics and Statistics. University of Allahabad as well as my home had an atmosphere best suited for Indian Administrative Service (IAS) exam preparation and it was understood that all good students would appear for the civil services exam.

At this point I was pretty ignorant about how to go about choosing a career. Of course, I had read about Marie Curie and Ramanujan from early childhood, but in University of Allahabad the best students were not expected to become researchers. One of my teachers, Dr. Pankaj Sharan, was a Ph.D. from I.I.T., Kanpur, and he encouraged some of us to apply to I.I.T. for M.Sc. So I applied to I.I.T., Kanpur for both physics and mathematics. As luck would have it, the physics test took place before the mathematics test. I was one of the ten students selected and I never appeared for the maths entrance exam.

The next two years I had to work very hard to keep up with the hectic schedule at I.I.T. I was the only girl in my class and due to my upbringing and Allahabad University's culture I found it difficult to interact with my classmates. However, I was lucky to be taught by some of the best teachers. One was then Prof. S.D. Joglekar later became my Ph.D. guide. I worked on Renormalization Theory and we published a number of papers. All hell broke loose at home when I announced that I was not going to appear for the I.A.S. exam. I was considered the brightest amongst the ten children, having topped almost all the exams from class one till M.Sc. They really thought (and probably still think) I had gone crazy!

In the meantime I had married Raghava, my friend and classmate from M.Sc. days. Both of us completed Ph.D in 1989 and he joined TIFR as a postdoctoral fellow immediately thereafter. I had two good offers both outside Bombay, but I was expecting my first child and decided to be with my husband at this

crucial time. I spent the next one and a half year looking after my son. When my child was an year old, I joined Saha Institute in Calcutta as a post-doctoral fellow, but my husband got a post-doctoral fellowship at State University of New York at Stony Brook. This offer was too good to refuse and once again I accompanied him, leaving S.I.N.P. after just three months.

It took us a while to get settled. When I had almost given up all hopes of continuing physics, my husband persuaded me to visit the Institute of Theoretical Physics at University of Stony Brook to meet Prof. George Sterman, a renowned theoretical physicist, who is also, as I learnt later, an excellent human being. He understood my dilemma about wanting to get back to physics and agreed to help me. He gave me a couple of papers and asked me to choose one for a seminar course he was offering that semester. One of them was on Light-Front Quantum Electrodynamics by Wilson and collaborators. I chose to present this one and this was the beginning of a totally new phase in my career. I spent the next year learning light-front field theories, working out things literally on my kitchen table and meeting Prof. Sterman occasionally for discussions.

My first research paper after Ph.D. was written from home. When I showed the results to Prof. Sterman he immediately said it was worth publishing in *Physical Review* and offered me a guest lecturer's position at the Department of Physics so that I could have a place to work and, more importantly, an affiliation. If someone were to ask me to single out one person who helped me to come back to physics after having taken a break for my family, it has to be Prof. Sterman. Not only did he provide me a platform but also gave me the confidence that "I can".

By the time I established myself as a researcher, it was time for my husband to come back. We returned to India in 1994. He joined Bhabha Atomic Research Centre (BARC) and I joined M.R.I. (now H.R.I.) temporarily while looking for jobs. Prof. H.S. Mani, one of the most inspiring teachers at I.I.T., Kanpur was the Director of H.R.I. and was keen to help me to get back to active research. My husband got an offer from I.I.T., Bombay, but whenever I applied for a job, the four-year gap came up as a negative point. Prof. Mani helped me to get a research associate position at University of Mumbai.

My younger son was born when I started working with Prof. Rohini Godbole at Bombay University. She also understood that for me my family and my career were equally important. Her unwavering faith in my potential and more importantly in my dedication to work has helped me to regain my self-confidence. I must say that she is the other person who has played a stellar role in my continuing with science.

I was soon selected as a lecturer in the same department and I am fortunate to have found a profession of my liking. Teaching is not just a job for me; it is a passion. I have also continued my research work in High Energy Physics. Quantum Chromodynamics or QCD keeps me occupied when I am not teaching. I have continued my research work on Light-Front Field Theories, which provide a hope to explain an important puzzles in strong interaction physics namely how quarks bind together to form hadrons.

My advice to young researchers would be to avoid any breaks in career: Keep in touch even if you have to work part-time. Whenever I applied for a job there was always a question about the four-year gap. Luckily I can reply that I did my first independent work during that break. Probably in my case, it was a blessing in disguise as I was able to stand completely on my own. Not all areas of research provide this luxury of working from home and not everyone is fortunate like me to be able to take a break and make a comeback at will.

It is very difficult in our society for a woman to be career-minded and still be devoted to family. I have tried to do both with only partial success on both fronts. Even this would not have been possible without constant help and encouragement from my husband. I fought my way through all prejudices and was somehow able to tackle the usual problems of not getting quality day-care and domestic help, but the biggest obstacle I faced was my own sense of guilt at not spending enough time with my children. Now I realise that indulging in those feelings was a mistake. Trying to be a superwoman only led to health problems and complicated the situation even more. The sense of guilt is bound to go away when you come to know that your kids are proud of you. It is better not to have such feelings from the beginning so that you can contribute in a more efficient manner to the profession you are passionate about.



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How I became what I am

Sushmita Mitra

I was born into a highly educated family in Kolkata on a cold December afternoon, the only child of Drs Maya and Girindranath Mitra. The doctor had wrongly pronounced me dead, even before I could see the light of the day. But luckily for me, I lived. My father was an agricultural scientist with the Indian Council of Agricultural Research. My mother was a professor of Botany at Bethune College in Kolkata – a leading women's college from where the first women of the British Empire graduated. Whatever I am today, I owe it to my mother's untiring efforts and continual sacrifice.

From her childhood my mother rebelled against the concept of preference for a male child that was prevalent in those days. She had the ambition to finish college, and she eventually obtained a Ph.D. in 1960 – also receiving the Agarkar gold medal of the Calcutta University in 1962, with a paper in the journal *Nature*! Setting aside such a promising research career, she decided to marry and raise a family.

I grew up with a working mother when that concept was still uncommon in Kolkata. However, I recall that my mother made every effort to spend quality time with me, and with her encouragement and support, I grew up in a healthy educational environment. My father's career at ICAR meant that he spent much of his working life outside Kolkata, in Shillong, Cuttack, and Hyderabad. Under this circumstance, my mother took care of my education as well as all other needs. My mother also took me along to her numerous botanical excursions. We traveled along the length and breadth of our magnificent country, getting acquainted with its rich and diverse history, vegetation and topographical regions.

My father suddenly passed away at the age of 53 years, and the

entire responsibility of the family shifted onto my mother. She inspired me to appear in the National Talent Search Examination, conducted by the National Council for Educational Research & Training. I was awarded the NTS scholarship, and it continued right up to my Master's level. I completed my Ph.D. in Computer Science in 1995 at the Indian Statistical Institute, under the supervision of the eminent scientist Prof. Sankar K. Pal. He has been another major inspiration in my professional career.

I have been working in ISI since 1991, publishing extensively and rising up the academic ladder right upto the level of a full Professor. My mother would often urge me to explore the possibility of merging Botany with the Informatics – and this is what I am doing in the integration called Bioinformatics! I only wish she were beside me today to share the joys of my professional domain. The logistic support provided by my mother helped relieve a lot of the burden of childrearing and allowed me to concentrate on research. It provided important emotional support to my daughter as well. My mother passed away almost suddenly in the summer of 2006. A part of me perished as well. Keeping in mind her happiness whenever I performed well in my profession, I believe I should continue with my work in fulfilling her goals.

My work on neuro-fuzzy computing has been internationally acclaimed, leading to several fellowships. I have written several books – Neuro Fuzzy pattern recognition: Methods in soft computing, Data Mining: Multimedia, Soft Computing, and Bioinformatics, and Introduction to machine learning and Bioinformatics. I am also associated in the editorial activity of several international journals, and worked as the programme chair of many international conferences.

I have not faced gender discrimination in any phase of my education and/or professional career. Wherever I went, I have always been a vocal proponent for women's causes. My mother has been a powerful influence in my life in this direction. She had dared to think differently. It is because of women like her, who walked before us, that we are able to achieve what we want with relative ease. Today, I strive to bring up my daughter by imbibing in her a similar conviction.



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Road to research

Anjali Mookerjee

From my childhood, I knew that mathematics was the stepping stone to enter the world of Science, and that was what together with Sanskrit, our elders learnt. And that I too would learn the same.

Mine was a 'joint family' of the feudal zamindari system, consisting of my father and his two older brothers, my grandmother, mother, two older aunts, and cousins and my brother and two sisters. Daughters were very well taken care of, including their education. My hometown was Chandernagore – a small French township on the banks of the river Hooghly. It had a French Convent School, a Church, and various other schools and colleges, and some French nationals.

I was a student of St. Joseph's Convent – where we followed Junior and Senior Cambridge Course. In my J.C. Course there was Mathematics and Hygiene and Physiology apart from the usual subjects covering History, Geography, English and French (compulsory!). No Bengali, no Sanskrit!

This combination of hygiene, physiology and mathematics was, for me, the first taste of the future Science Cosmos. I liked solving arithmetic and geometry problems, and watched with wonder my teacher (who was a Nun) perform dissection on a toad and expose the inner system. My father was a quiet person with immense intellectual yearning and depth. My

mother, married at eleven but trained by my father, could recite Tagore fluently till the end of her life and taught me my mother-tongue. My maternal grandfather was another strong influence at that point of time.

Then there was turmoil in the country – the second World War, famine, Gandhiji's August movement, the INA-movement, partition, the end of Foreign rule and India's Independence !

It was somewhat similar in my personal life also – much turmoil and movement. Marriage before my Junior Cambridge Exams (which made me move to Calcutta) – in spite of which I sat for the exams and did fairly well – then childbirth, and many mishaps and many other breaks in the smooth running of academic and family life.

For about 5 – 6 years there was a break in my formal education, but this did not deter me from academic pursuits. I started learning Sanskrit at home, from Pandit Sivaprasad Bhattacharya – and this opened up a panorama of another world, a treasure house which has sustained me throughout my long life.

In between, my brother came to Calcutta to study Physics Honours in Presidency College and stayed with me. This made me think of starting my formal academic career again. I had to sit for Matriculation Examination as a private candidate and obtained a 1st Division and the subjects covered were History, Geography, Maths, English, Bengali, Sanskrit. As Presidency did not allow girl students in the Intermediate (i.e. XII) classes, I went to Loreto College with Physics, Chemistry, Maths and French as an 'additional subject' and English and Bengali. There were very modest labs, but very sincere teachers – and from here my liking for science started crystallizing. I can still remember Prof. Bose-Majumder drawing geometry figures on the black-board, and Prof. Ganguli demonstrating Physics experiments in the lab! In the final University exam I obtained a 1st Division, but this was due to my brother helping me at home throughout – especially with my Physics and Maths.

Now the portals of Presidency College were open to me. The teachers here were a different set – which is partially true even now. I had physics as my Honours (or Major) and Maths and Chemistry pass (minor) subjects. I was interested in experiments

as well as in theory. In spite of my many difficulties at home – as a mother and a housewife – I did manage somehow.

We had the very good fortune of having Professors like K.C. Kar, R.L. Sengupta, P.C. Mukherji, P.Sen, P.C. Bhattacharya, and S.N. Bose, M.N. Saha, B.D. Nag Chaudhuri, S.N. Ghoshal and others. We were the last batch of M.Sc. Physics students who had the very good fortune of watching Prof. S.N. Bose lecturing on Special Theory of Relativity. He retired that year. In M.Sc. Physics we had to opt for a 'Special paper' and my choice was 'Nuclear Physics'.

That was the time when scientists and others were aware of the devastating effects of nuclear energy. The atomic bombs had been dropped on Hiroshima and Nagasaki in 1945. A new research area was developing – that of 'biophysics'. It was Prof. M.N. Saha who had the vision of establishing the Department of Biophysics in the Institute of Nuclear Physics and appointed Prof. N.N. Dasgupta – a Cosmic Ray Physicist as its head. Initiation of my research career started as a Ph.D. student under the guidance of Prof. Dasgupta in 1957. I learnt many many things from Prof. Dasgupta – as a scientist, as a teacher, as a human being. My first research note was sent (and accepted) in *Nature* in 1959 and he omitted his name as one of the authors. He instructed me to give him thanks for guidance. This was a life-long lesson for me (and all his students).

Listening to scintillating lectures by national and international scientists was something we students enjoyed, and these enriched our understanding very much. We had plenty of opportunities for this and were encouraged by our teachers. I still retain the habit. I remember listening to Homi Bhabha at the Bombay Science Congress, G.N. Ramachandran, Dirac. Emilio Segré – these are the seeds of a future life – form that are sown in the mind and act as intellectual fertilizers.

While doing my Ph.D. I accompanied my husband (the late Prof. Sivatosh Mookerjee) a biologist, who went as Visiting Fellow at the Rockefeller Institute in 1960. After a few months it was suggested that I visit Sloan Kettering Institute for Cancer Research which had a Biophysics Division. I went, with my first pub-

lication copy of the Nature article, and was asked to join after some time, as my visa needed to be changed. Very fortunately Dr. J.S. Laughlin – the Head – allowed me to use the data I obtained in that lab later for my Ph.D. thesis work. A publication in Radiation Research came out of that study. My exposure to cancer therapy, cancer patients in the attached Memorial Hospital – was a turning point for my future research life. I saw Leo Szilard, one of the brains behind the ‘nuclear explosion’, suffering from leukaemia, and undergoing chemotherapy which was at a very early stage at that time. He had ‘donated’ himself for research.

On my return to India I submitted my thesis, got my Ph.D. and joined Saha Institute in the Dept. of Crystallography and Molecular Biology and ventured deeper in the study of Molecular Biology.

In 1972 my husband joined the School of Life Sciences, J.N.U., New Delhi. The only other Science department then was the School of Computer and Systems Sciences and Shri G Parthasarathi was the Vice Chancellor. I came from Calcutta, keeping my lien at the Saha Institute, and as a Visiting Fellow was teaching Biophysics to the students of School of Life Sciences. It was in 1974 that the present School of Environmental Sciences was formed, and then Dean Prof. (Late) S.N. Biswas and few other colleagues we toiled day and night trying to give the new School and the new subject a comprehensive form.

The SES took about two years to take off, after which there was no looking back! Without teaching research is barren and without research, teaching is stale. As teachers we are supposed to inspire the students, but, students inspire us too!

The core of our research activities was centred around drug and radiation effects, separately and in combination on cell and cellular components, and on drug structure and modeling. The course that I attended in ICTP Trieste (1980) helped a lot.

On my retirement from J.N.U. in 1991 we came back to Calcutta and very unfortunately I lost my husband in 1993. He stood like a rock behind me in all my travails. Now, I look after the ‘Sivatosh Mookerjee Science Centre’ which is a part of the Asutosh Mookerjee Memorial Institute. My inner source of strength and inspiration is the Belur Math, Ramakrishna Mission. It has been so since my girlhood days from when I was 12 years old...



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Successfully combating prejudice

Sipra Guha-Mukherjee

I decided to study botany because it was my favorite subject in school. As a school student I was awed by the contribution of Sir Jagdish Chandra Bose, and fascinated by his work that showed that plants were living organisms and had a metabolism similar to that of animals. His hypothesis that ascent of sap in plants is due to pulsatory activity of an inner layer of cortical cells (a theory no longer tenable) infused a huge excitement in me, as earlier I used to think that plants were inert objects which could never respond to any external stimuli. As a student in classes five and six, I developed a strong determination to find the locations of the “heart” and “brain” of plants and to understand the way they functioned. In classes nine to eleven when we studied botany more seriously, I was taught several phenomena regarding plants but nothing about how plants respond to external stimuli.

After finishing school, I joined the B.Sc. (Botany) Honors course at Delhi University. It was an amazing experience as the whole department was vibrant and throbbing with activity. The teachers were so inspiring that all the students in our class looked forward to their lectures. B.D. Sanwal, H.Y. Mohan Ram, S.C. Maheshwari, I.K. Vasil all were excellent teachers who later rose to

top positions in their respective fields. My major inspiration came from Prof. P Maheshwari, a world-renowned plant embryologist, who headed the department. P. Maheshwari made it his mission to inculcate students' interest in Botany by applying various teaching innovations. The whole department was in the birth pangs of the plant tissue culture. The intellectual ferment had a major effect on all of us.

My doctoral research under the guidance of B. M. Johri dealt with the tissue culture of flowers of *Allium cepa*. For postdoctoral research I joined S. C. Maheshwari in the same department. This was a very rewarding period. I worked on various aspects of biochemistry of differentiation in plants, effects of plant hormones on transcription, and stumbled upon production of haploids through anther cultures of *Datura innoxia*. I felt very privileged as I was at the right place at the right time. Our culturing anthers of *Datura* was an extension of several projects in my scientific career. I have written a detailed account of the discovery of anther culture in a turning point article published by the journal *In Vitro Plant*, Volume 35, 1999.

I continued my post-doctoral studies at Michigan State University with Robert S. Bandurski and later with J. E. Varner at the AEC Plant Research Laboratory where, I mainly worked on subunit structures of Aspartate transcarbamylase and isozymes of peroxidases. Although my work on haploid production was published in *Nature*. I did not find any enthusiasm or even appreciation of this work amongst fellow scientists there. This was primarily due to the excitement of new discoveries in molecular biology that overshadowed all other good research, a trend that still continues.

In Europe the situation was different. I was invited to present my work at the EMBO symposium on Haploids in Italy in 1971. The next symposium on Haploids was held in Guelph, Canada, where again I was invited to present a paper. At the XV International Congress of Genetics held in New Delhi in 1983, I met Professor Hu Han, Director of the Institute of Genetics of Academia Sinica, China, who appreciated our work on anther culture and remarked that our work was responsible for a substantial

change in the agricultural economy in China. This was one of the greatest moments in my life. He invited me to Beijing, China, to attend an International Symposium of Genetic Manipulation in Crops in 1984 which was the third international symposium on Haploids.

While I was teaching at West Virginia University in the U.S., in 1972, I was invited to take up a faculty position at the newly established School of Life Sciences at Jawaharlal Nehru University, New Delhi.

I was very happy to get this opportunity. At JNU, no one interfered with my work we also had the freedom to frame our own syllabi, I got adequate grants from U.G.C. C.S.I.R., DST and DBT to support my research. My decision to continue postdoctoral work both at Delhi University as well as in the U.S despite the negative pressures was most crucial in shaping my scientific career.

My decision to opt for higher studies was frowned upon by my relatives and friends, and I received no encouragement or appreciation from them. Even scientists like P. Maheshwari and B. M. Johri thought it improper to appoint a woman scientist as a faculty member in the department. With this bias in place, no woman scientist could rise above a certain level and thus we felt mentally inferior to male scientists.

Even in the U.S. the situation was not very different. I felt I was swimming against the tide. Despite the negative attitude of society and of most male scientists towards women's role as research scientists, I did get inspiration and encouragement from some senior scientists who helped me sustain my interest in research. Without the support of such people there would be a scarcity of women scientists today. Most notable amongst them is Dr. M. S. Swaminathan, who in his mild way always inspired and profusely encouraged me to strive ahead in my research goals. It was unfortunate that I could not find any role model amongst women scientists because they were not well-known personalities. Men mostly ignored them. Great women scientists like Madame Curie or Rosalind Franklin were too distant to influence my career in India.

In those days I did not hear about any woman in India who had made a mark in science. In later years, whenever I discussed this aspect with my teachers I heard that although women were as intelligent as men they could not achieve the same level of success because of their different social commitments.

Today when I look back, I feel fortunate about the events and achievements in my career. I have no regrets and if at all I could change anything I would certainly like (while continuing with my research!) to also understand the psyche of many of my contemporary scientists and administrators and their attitude to women. I feel a lot of precious time was wasted, smoothing ruffled feathers and pacifying many important fellow scientists, administrators and vice chancellors. It is important to eliminate the damage caused by such attitudes so that coming generations of women scientists will not have to waste time combating them.



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The unfathomable beauty of mathematics

Indira Narayanaswamy

Although I come from a family of agricultural landlords from a remote part of South Kerala, the importance of good education, particularly for girls, has always been a top priority for all the family members. My father was a lawyer by profession, practicing at Alleppey, a small town in the erstwhile Travancore. My mother had graduated from Madras University, but decided to be a homemaker. The families of both my parents were very academically oriented and well educated. The environment in which I grew up instilled in me a sense of discipline to excel in whatever I did. I had my schooling in St. Antony's Girls High School and St. Joseph's College for women and my graduation and postgraduation in Mathematics from Sanatana Dharma College, Alleppey.

My love and fascination for Mathematics began very early and was kindled and nurtured by my parents. Even as a child, my father used to give me mental sums and gave me many hints on how to do mental arithmetic. This went a long way in kindling in me a life-long fascination and love for Mathematics which I continue to cherish.

I have been very fortunate in having excellent teachers both at school and college, who nurtured my interest in Mathematics. I had great teachers at St Joseph's who nurtured my love for Mathematics after spotting my keen interest in the subject. It was under their tutelage that I appeared for National Science Talent Search Examination conducted by NCERT, New Delhi.

Highly inspired by reading books like Principia Mathematica, a three volume work on Foundations of Mathematics, which threw light on the attempts to derive mathematical truths from a well defined set of axioms and inference rules in symbolic logic, I was keen to pursue a doctoral programme in Mathematics. My family was apprehensive about my higher studies in an abstract subject like Mathematics and my being away from home for the first time when I went to Chennai to pursue my Ph.D. at MATSCIENCE, now referred to as IMSc, under the able guidance of Dr. K. R. Unni, in Functional Analysis.

Half way through my doctoral programme, I married Mr K. S. Narayanaswamy, a Chartered Accountant who was working for a Bank in Ahmedabad. I had unconditional support from him to pursue my studies and I used to make frequent visits to MATSCIENCE to meet my guide for discussions. With the support from my husband's parents also who were residing in Chennai and for whom education and knowledge were invaluable, I could complete my studies and submit my thesis.

After completing my Ph.D., I went on a postdoctoral fellowship to the University of Pittsburgh, where I worked on smoothing of curves and surfaces using spline functions.

I then, joined Aeronautical Development Agency (ADA) at Bangalore, an autonomous body under the Ministry of Defense, as a scientist. ADA is the nodal agency for the design and development of the multi-role supersonic fighter Light Combat Aircraft (LCA), now christened as TEJAS, to primarily meet the requirements of Indian Air Force and Indian Navy.

My becoming a mathematician and a scientist was purely out of my choice and innate passion for science. I have been fortunate to get undaunted support and encouragement from my fam-

ily members. I personally feel that science offers excellent career for women who are capable of multiple handling roles with dexterity.

Our policy makers should look into the possibility of offering flexi-time working hours for women with small children, thereby giving them more flexibility to combine the family and career, thus helping them reach greater heights in their pursuit of science.



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Guess what I am doing now!

Shobhana Narasimhan

From the time I was very young, my favourite subjects were mathematics and English. When people asked me what I wanted to do when I grew up, I used to have a hard time choosing between being a mathematician and being a writer, though I was always a bit embarrassed to say this, since my father was a mathematician and my mother a writer – I was afraid that people would think that I was displaying a singular lack of imagination in my choice of careers! After my ICSE, I shocked many people by pausing to think about whether I wanted to study further in the sciences or the humanities – it was assumed that all “toppers” would automatically choose science. As it happened, however, I did fulfill expectations by joining the science stream, having reasoned that it was easier to become a scientist who wrote, than a writer who did science in her spare time.

Though I did well in all science subjects, in my schooldays I had a severe physics phobia. This was probably induced by my first physics teacher, who was a real martinet, and made no secret of her dislike of me. She made us learn physics largely through rote memorization, which did not appeal to me, and I remember

sobbing hysterically both before and after my ICSE physics exam. If someone had predicted, at that time, that I would become a physicist, I would have told them that they were crazy! In fact, when I joined St. Xavier's in Bombay for Junior College, I was quite disappointed to discover that physics was a compulsory subject for science students.

Funnily enough, it was my interest in writing that led to my overcoming this aversion to physics – I was asked to script a radio programme for children about Albert Einstein, and when I started reading up about his life and his work, I became fascinated by quantum mechanics and relativity. I learnt more about these subjects in my classes, and was fortunate to have some excellent teachers, such as Sudhir Paranjape, R.V. Kamat, Melky Alvares, Jehangir Mistry and Rajkumar Rao. I think I literally fell in love with physics, it became an obsession, and when my father bought me physics textbooks for my birthday present when I turned sixteen, far from feeling let down, I was actually rather gratified! Socially, my first two years at Xavier's were hard...from being in an all-girls' school, I was suddenly in a class of 4 girls and 75 boys, most of whom refused to talk to me; only much later did I discover that this was partly because of pique at my having done well in examinations. Looking back, maybe I should not entirely blame them, I must have seemed pretty weird – I chose to spend my free time in the library rather than the canteen (I have always read widely and voraciously), and grew misty-eyed when thinking of Werner Heisenberg and Ernest Rutherford, rather than John Travolta or Amitabh Bachchan!

Of course my classmates also found it odd that I did not want to do engineering or medicine! Despite being academically successful, it was completely clear to me that I wanted to do a B.Sc. in physics, also at St. Xavier's – and I have never regretted this decision. I was fortunate in having parents who put no pressure on me, and left me to decide what I wanted to do with my life. After that, I did an M.Sc. in physics at IIT Bombay (where S.H. Patil was inspiring and supportive), and then, very much to my surprise (my confidence hadn't increased hugely since my ICSE time!), I was admitted to the Ph.D. programme at Harvard Uni-

versity in the USA, which was regularly ranked as the topmost university in physics. I went there planning to do either astrophysics or high energy physics, but after a year of coursework, I chose to change fields to condensed matter theory, which is the area I still work in.

After my Ph.D., I worked as a postdoc – first at Brookhaven National Laboratory in the USA, and then at the Fritz-Haber Institute in Berlin, Germany. Though I enjoyed my years studying and working abroad, and made several close friends there, I always felt that India was “home” and where I belonged. So I was happy to accept the offer of a faculty position at the Jawaharlal Nehru Centre for Advanced Scientific Research in Bangalore, where I continue to work to this day.

The field I work in is called ‘ab initio density functional theory’, this is an approach to calculating the properties of materials from ‘first principles’, with no empirical input apart from atomic numbers and atomic masses. For many years I focused primarily on studying the surfaces of objects, but nowadays I am also interested in studying the properties of very small nanosystems (composed of tens of atoms), more specifically, I am interested in studying how the structural, electronic, magnetic, chemical, mechanical and thermal properties of such systems change when their size is changed.

I like doing research because of the intellectual freedom it provides, as well as the challenge of puzzle-solving. I feel a huge satisfaction when I can discern a pattern amongst a collection of seemingly random numbers (from experiments or computation), or when I can explain some phenomenon that seems contradictory or counter-intuitive. Moreover, though I can see the appeal of knowledge-for-knowledge’s-sake, I like the fact that my research may find applications in areas such as the search for better materials for magnetic memory storage, or better catalysts for reducing environmental pollution. I also enjoy teaching, especially trying to teach in a way that emphasizes conceptual knowledge rather than merely facts or formulae.

Almost thirty years after I first decided I wanted to be a physicist – well, I have pretty much exactly what I wanted! I feel

it's wonderful that I am paid to do what I enjoy doing, and that I have the freedom to pick how I spend my time. Though my career path from then to now might seem straight, determined and successful from the outside, on the inside, it has not always been so.

There have been times when I have doubted whether I was good enough to succeed in this field that so fascinated me – either because of my own insecurities, or because of negative remarks from others, or because it seemed overly competitive. But then I tell myself...heck, no, I am good at this AND more importantly, I like doing it...and I feel like hunting out that first physics teacher who so terrified me, and saying: “You used to say I’m no good at physics...well, guess what I’m doing now?!”



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A career in mathematics

Mangala Narlikar

I can only describe myself as a part-time scientist, if a pure mathematician can be called a scientist at all. I decided to write about my experiences because they perhaps represent those of a section of women of my era.

In school and college I was considered a bright student and won, without much effort, the middle school and high school scholarships given by the government. One of my high school teachers, Mrs Kamat, who loved me, had noticed early on that I suffered from a lack of ambition. She also noticed that some other students, who were very ambitious, worked hard and would strive to get a better rank, whereas I was happy-go-lucky. I was interested in studying mathematics. I was advised that the maths courses in science as well as arts streams were the same and M.A. (maths) and M.Sc. (maths) were valued equally; so I should join for the arts stream and not waste my time doing physics and chemistry practicals in the afternoons. I could devote time to other hobbies like reading and painting. So that is what I did. The other subjects I studied in the first two years of college were world history, economics, civics and Sanskrit. I enjoyed them all. Later on however, I realized that though I enjoyed studying pure maths, I was not familiar with a lot of applications of maths because I had not studied physics enough. I would now advise anyone who wants to

study maths to choose M.Sc. with maths as it also includes studying physics at a respectable level.

I joined the school of mathematics at T.I.F.R. for research. However, even while I was studying for the M.A., my family was pressing me to get married. Soon after a girl was twenty, she was expected to get married and raise a family. Just after I was promoted to be a research associate at the School of Maths, I got a good proposal and I decided to accept it. I had accepted the philosophy of my parents, namely, that the first priority for a young lady should be the family and her spare time can be used for any study or hobby.

After marriage, we moved to Cambridge, England, where my husband was working at the time. Fortunately, my husband, a well-known astrophysicist, respected my wish to study mathematics although he too did not wish me to prioritize career over the family. In Cambridge, I attended some graduate lecture courses and also taught a course and supervised some undergraduate students. But my research had come to a stop. I was busy setting up a home, experimenting with cooking, enjoying a good social life and traveling. Later, our two daughters were born in Cambridge.

However, when we came to settle down in India, my husband became a professor in T.I.F.R. and we got accommodation just across the street from T.I.F.R. That was a lucky break for me. It was not difficult to visit the school of mathematics again and pick up the threads of maths research in my spare time. I started attending lecture courses and working in Professor Ramachandra's group on analytic number theory. I did not have to waste time commuting as many people in Mumbai do. With aging parents-in-law and two small daughters to care for, my work was slow and by the time my thesis was completed and a Ph.D. was awarded to me, our third daughter had arrived.

I worked as a pool officer in T.I.F.R. for a couple of years and published a few papers. I taught maths at the University of Bombay which had by this time moved to a northern suburb, very far away from T.I.F.R. So I went once a week as a guest lecturer and gave two lectures to M.Phil. students. In 1989 we moved to Pune, and here too, I worked as a part time teacher at the depart-

ment of mathematics at Pune University.

In retrospect, I feel that I should have striven harder and continued my research all through. The main problem, as my old teacher noticed, was my lack of ambition. So I cannot blame anyone else. But times are changing fast. My youngest daughter, Leelavati, used to be disappointed when she came back from her primary school if I was lecturing at the university and was not at home to welcome her. But the same girl after about four or five years started saying that the mothers of all her friends had jobs and worked all day, so why didn't I do the same! We have three daughters and they all are now following their careers in spite of family responsibilities. The eldest is a professor of biochemistry and the other two do research in computer science. They have very busy lives and the full support of their husbands.

I must mention that although I missed being a full time scientist, I did enjoy housekeeping, bringing up children and watching them grow, as also sewing clothes for them, cooking, and traveling. I was able to spend a lot of time for and with my family. As I grew older I realized that I enjoy teaching maths to bright students as well as those who are afraid of it. It is rewarding to help school kids to understand and enjoy mathematics which is often a dreaded subject. So I wrote a book on how to make mathematics interesting and accessible to students who are scared of it.

My story is perhaps a representation of the lives of many women of my generation who are well educated but always put household responsibilities before their personal careers.



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Off the beaten track

Chanda Nimbkar

How did I end up writing for ‘Lilavati’s daughters’ when my entry into the field of science was through the back door, so to say? Wasn’t I the one who refused to walk on the beaten track and opted for the commerce stream rather than science even after getting a high score (third highest in Maharashtra) in the SSC exam in 1976? Yet I am now immersed in the science and practice of Animal Breeding and feel like I have found my calling in life. I can live on my farm near a village, a comparatively pollution free and more or less peaceful life, have a career in a challenging and exciting field and help to improve productivity of local sheep and goats and incomes of the people who rear them. It was the right thing to do to give up the prospect of a career as a chartered accountant, when I started to feel stifled going through account books all day, and to embark on a new path in farming although I did not know where the path would lead.

I am glad that the inability to know whether I wanted to do a career in arts, science or commerce at the young age of 16 did not put too severe a limit on my future choices. Now I do regret, however, that I do not have the basic training in science which a B.Sc. gives. If I could turn the clock back, I would enroll for a B.Sc. But it is too late for that! I am glad though that I took Advanced Statistics as my special subject in T.Y.B. Com. My field of

Animal Breeding is based on statistics, and that early background helped me a lot later although I didn't know it at the time. My knowledge of accountancy is also very useful to me now in my administrative duties which I have to carry out as the head of a division of our Institute. The one year Master's degree in Animal Breeding at Edinburgh University six years after my Bachelor's degree in Commerce was really tough but I found I enjoyed the rigour and discipline of 'quantitative' or 'statistical' genetics.

After the MSc, there was an offer of a PhD scholarship at Edinburgh University. Others might have found this tempting, but I refused it because I wanted to come back and work on farm animal breeding for a few years, and then select a relevant topic for my PhD. I wanted my PhD thesis to be practically useful; not just academically interesting. So I came back in 1990 and worked in the Animal Husbandry Division (established that year) of our Nimbkar Agricultural Research Institute. My father had established NARI in 1968 for research on improving the yield of irrigated crops such as sunflower, safflower and sweet sorghum. The work was novel and interesting; we were able to get some funding and worked with enthusiasm.

The opportunity for another PhD scholarship did not come along until 2002. But when it came, it was exactly what I had wanted; so I was glad I had waited. This was the John Allwright Fellowship offered by the Australian Centre for International Agricultural Research which was funding our project on developing 'Prolific worm-resistant meat sheep for Maharashtra'. I did a PhD at the University of New England in Armidale, Australia, which is one of the top universities in the world in the field of animal breeding. My thesis was based on the results of the introduction of a gene for twinning into Deccani sheep which are reared for meat production. The gene known as the Booroola fecundity gene originated in the Indian Garole sheep from Sundarban in West Bengal, was exported unknowingly (in the sheep) to Australia in the late 18th century and discovered there in a strain of Merino sheep in the early 1980s as the first known single gene influencing lamb production. The causative mutation and a DNA test to detect it were identified in New Zealand in 2001. Our Institute was the

pioneer in India in proving that Garole sheep possessed the same gene and introducing it into the Deccani breed to gain a minimum 40% increase in weight of lamb produced per ewe carrying the gene. Our work drew attention to the Garole breed and several Government of India Institutes and Universities started studies involving this breed and the gene it carried.

We have now developed the NARI Suwarna strain of Deccani sheep with the ability to give twin lambs and have disseminated it into the flocks of local shepherds as well as to far-flung states such as Andhra Pradesh and Jammu and Kashmir. About 30 smallholder shepherds around Phaltan have twinning sheep in their flocks and are reaping the benefit of having surplus lambs to sell. I really enjoy working with sheep and the shepherds who understand them so well. It is a joy to be able to take the results of research to the end-users. We have also started doing more training and extension among shepherds.

I could not have come such a long way without some important people in my life. I am grateful to my parents for having faith in me and letting me find my own way while providing lots of encouragement and support, financial and emotional. I am also grateful to my father because the Institute he established and built up over the years provided me a readymade place to work from. Having this strong institutional background has benefited me tremendously although finding sources of funding for our unusual long term projects of genetic improvement of sheep and goats is a challenge. My husband Gavan has been a pillar of strength and the knowledge of his unfailing love and loyalty, my anchor through the difficult years of learning a new science and charting a course of meaningful and useful work for myself and my Institute. I also learnt from him how to maintain the balance between 'work' and 'life'. It is still early in my career and I have a long way to go. We have to build up more credibility for our Institute to overcome the prevalent prejudice against NGOs – especially those involved in animal research. I am still growing personally and learning to find a balance between perfection, efficiency and what is possible. The future is full of challenges and the joys and excitements of conquering them such as our latest CSIR award for 'Science and Technology Innovations for Rural Development'.



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An Oceanographer's Life

Aditi Pant

When I was 10 years old my mother taught me how to cook rice, dal and potato sabji. I was made to practice the process until I was able to achieve somewhat edible results every time. What my mother aimed for was consistent results, not merely edible results – because consistency meant “paying attention” and “knowing what you were doing” and “measuring things correctly” and so on- but my hands never could keep pace with my mind and she was forced to accept “atleast she will never go hungry” kind of edibility. I have often thought that this was the foundation for my career in science, because although I was hopeless at practical chemistry and biology, I could sort of see the pattern of things in my mind. I suppose this made it inevitable that I would largely depend on instrumentation for quality data, whether it was nitrate levels in the open ocean or rates of photosynthesis in mangrove swamps.

Perhaps the most important factor which influenced my choice of career was my father. He had a keen interest in how things worked and why, and dinner table conversations varied from steam engines to stars. Being used to hiking and trekking – another of my father's hobbies – I wanted a career which allowed

freedom of movement, not only of thought. At about this time I was completing my BSc at the University of Pune, and a friend of my father's gave me a book by Sir Alistair Hardy called "The Open Sea". The book described the life of plankton as observed by this Cambridge biologist and I was hooked for life!

Money was always tight and my mother had always told me that higher education abroad was simply not affordable so it was a joyous occasion when I got a US Government scholarship to the University of Hawaii. A thesis required 24 credits as part of the Master of Science programme, so when it came time to choose a subject I was professionally interested in the plankton to which I had been first exposed through "The Open Sea". The more I learnt of biology in the oceans the more interested I became in photosynthesis in plankton communities. Plankton are a highly diverse community of organisms some of which photosynthesize, still others graze on them, secondary grazers feed on the grazers and the bacteria recycle the nutrients back to the photosynthesizers. And all of this happens in water masses, some as large as continents, which are defined by the physics of density, shear, bottom topography and wind, and the effect of the rotation of the earth, moon and sun on that very fluid substance water.

My MS thesis was on the effect of tropical light intensities on photosynthesis by natural plankton communities and the nature and amount of reduced carbon flow from phyto-plankton to bacteria. It proved difficult to calculate rates of transfer directly in the sea and I and my guide, Dr M S Doty, veered round to the conclusion that I needed a single alga- single bacterium model before an entire community could be studied. Fortunately for me Professor G E Fogg FRS of Westfield College London University (UK) agreed with me. With an MS in my pocket, and after a two and a half hour grilling at Westfield College, when Professor Fogg offered to show me around his lab, I knew I was in! Later I got an SERC grant and a stipend for these studies so I was able to eat as well as work.

During both MS and PhD. a constantly recurring question was: What next? As I neared the end of my experimental work for the PhD. I had my sights on a couple of labs where I

would have loved to work, but in the meantime I met Professor N K Panikkar, a senior scientist with CSIR, who was the founder-Director of the National Institute of Oceanography, (NIO) Goa. Our wide-ranging discussions with him ended up with the question of job availability in India. One of us asked rather bitterly, "Does India really need us, Professor?" Remember this was 1971/72 and to my generation it seemed as though India really did not care what became of her youth. Also jobs were scarce. Dr Panikkar looked very grave and said "All I know is that there is a lot of work waiting for the person who has the guts to take it up. Of course you will get far better salaries just about any where else". Perhaps it was this challenge, or perhaps it was the thought of my father's disappointment if I chose to settle abroad, or perhaps I was tired of "explaining" India to people who had never left their own front doors. For whatever reason, I dropped all my plans for tenure and post docs and everything else and applied for a Pool Officership in 1973 and returned to India. I have never regretted it.

At NIO between 1973-76 we were bound by the exigencies of our situation to coastal studies and we must have covered the whole of the west coast of India from Veeraval to Kanyakumari and the Gulf of Mannar by vehicle and country fishing craft. We spent nights sleeping on the beaches because accommodation was not available and the team, whether scientist, driver or student worked together to complete the planned objectives. I don't remember worrying about food or water or privacy, we ate whatever the local teashop supplied us, mostly bhajjias and jaggery tea. Very often I was the only woman on the team. Local villagers, especially the women, sent their husbands or brothers to find out whether there was anything I wanted, including hot water for bath in their own huts! This special treatment resulted in much leg pulling by my colleagues about "women" scientists, but secretly they were rather relieved that they never had to worry about me. Much of my spare time was spent in telling the women in my bad Hindi just what we were trying to investigate and I learnt over time to explain our work in terms to which they could relate: fish catch. It also helped me to focus on the importance of the work that we were doing. Those were great days. The Institute was small, friendly

and every one knew their own responsibilities and those of the team.

The Antarctic was special. It is every oceanographers dream to visit the Antarctic and when my chance came I grabbed it with both hands. The NIO had a 10-year programme in the Antarctic Ocean for studies on food chain physics, chemistry and biology.

By 1990 I had moved out of NIO, after 17 years there, to the National Chemical Laboratory in Pune and spent the next 15 years studying enzymology of salt-tolerant and salt-loving microbes involved in the food chain. Although the work I did at NCL was completely different in its nature to what I did at NIO I learnt almost as much in Pune as I did while still at University, and during my early years in Goa. It is now difficult to decide which "avtar" I enjoyed more.!



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The long way home...

Sulabha Pathak

At age five, if someone had told me that I would end up a scientist pursuing research in laboratories across the world, I would have laughed. I was aware of only two burning passions – to teach and to see the world. I was pragmatic enough to know that while my first goal was achievable for a girl from a middle-class family in recently independent India, the second seemed destined to remain a dream. Still, the gypsy in me balked at the idea of living a conventional life.

I knew I wanted to teach. But what exactly? I enjoyed all the subjects I took for my SSC, be they languages (I fancied myself an author) mathematics or sciences. While I was frantically searching for a subject to teach, my father thought that research was my calling. He argued that in India's educational set-up, choosing science left open the option of reverting to arts later. On the first-day of admissions, the queue for science admissions was much smaller than that for arts. The less conventional choice won.

College-level physics and maths were enjoyable, but biology was where my heart lay. People automatically assumed I would waltz into medicine, but a doctor's lifestyle, which left little room for hobbies and other pursuits, was not for me. Microbiology, at that time a relatively new field, offered the chance of a

college teaching position directly after a master's. Much to my parents' chagrin, although my marks would have assured me a seat in medicine, I chose microbiology.

At twenty-three, I was poised to finish my master's. To my mother's and grandmother's way of thinking, this meant a wedding was on the cards. My father, on the other hand, thought it would be a mistake for me to marry before getting a Ph.D. I was ambivalent; marriage was not an option unless it was to the right guy. As fate would have it, Sanjeev was just a common set of friends away. I chose marriage despite my father's disappointment. It was much later that I came to truly appreciate how exceptional my father's stance had been. He never confined me to a gendered role; he insisted his daughter live as an equal in a man's world.

The completion of my master's saw me lecturing. It took only a couple of years for restlessness to set in. I enjoyed teaching, but I needed another challenge. I then wrote my first book, *Notes in Microbiology*. It kept me occupied for a while, and then I started dabbling in research projects. It turned out my father was right – in research I found my calling.

At this point fate intervened. Sanjeev was transferred to the Netherlands. He was not sure how I would react to his news – I had a permanent job that I clearly loved. However, for the gypsy in me, it was a chance to see the world. Giving up my job was an easy decision because I knew myself well enough to realize I would always find something to do. Within a week of our arrival, with three-year old Gauri in tow, I approached Prof. Rob Benner at the Erasmus University's immunology department for a voluntary job. I explained that I would work only the hours that Gauri was at school. Luckily, Rob appreciated my forthrightness and passion for research. Within a month, what had started as a voluntary job was converted to a salaried position. Unbeknownst to me, my long march to a Ph.D. had begun.

A couple of years after joining Erasmus, I started on a Ph.D. track. It would not prove easy. First, Sanjeev was transferred back to Mumbai. Second, Huub, my immediate supervisor, accepted a two-year position at Stanford. I toyed with the idea of letting Sanjeev return alone, but the emotional and economic toll

was unacceptable. Rob was very supportive and understood my compulsions. Fortunately, I was not in a competitive field, so Rob suggested that I write a paper on my data while in India and then restart my research once Huub finished his stint at Stanford. While I waited to recommence my doctoral work, I began to work as an industrial research consultant and dealt with a gamut of disparate projects from acne to herbal medicines to washing powders.

When I revisited my doctoral track, I battled frustration as I worked in stretches of a few months at a time at Erasmus before returning home to analyze the data and think up new experiments. Then came the next round. My Ph.D. had morphed into a long-distance, part-time venture. I survived the seemingly interminable project only because of the support and understanding of my family and friends. I finally stood before my thesis committee defending my doctorate almost a decade after I had first started working at Erasmus.

By this time, we were in a small town, Lote-Parshuram, half-way between Mumbai and Goa. Gauri was soon to enter class ten, and I did not want any upheavals in her life. I decided to stay at Lote for the next two years. To use the time fruitfully, I teamed up with a friend and turned to a long-cherished dream of writing an immunology textbook priced for the Indian market. This was before the easy availability of information of the internet era. Library access was limited. My arms full of bound journals from the Haffkines Institute library (in Mumbai), I would trek to the corner copy-shop so that I could carry relevant references home with me. By the time I finished the book and Gauri passed class ten, fate intervened, once again in the person of Sanjeev. He was offered a position in the U.S.. I jumped at the opportunities this presented for both travel and research. After years of self-imposed discipline, returning to regular working hours as a post-doctoral fellow in immunology was a sheer joy.

After the appointed three years, Sanjeev was ready to return to India; I was not. My stint had been very fruitful and opened up the possibility of pursuing research at some of the most prestigious institutes in the U.S.. Sanjeev and Gauri knew that their lives had always taken precedence over my career; they told me

now my dreams should come first. From a long-distance career to a long-distance marriage – for a year and a half, I lived the single life in Boston, indulging my passion for research at M.I.T. and Harvard.

The year spent alone provided ample time for introspection. After the book, research projects, Ph.D., and postdoctoral stints, it was now time to do other things with my life. I have never been ambitious about my career, only about my work. When I returned to India, I worked on the second edition of the immunology book while searching for a position that would allow me room for other pursuits. I am now a post-doctoral fellow at T.I.F.R., lucky to be with a boss who understands my perspective. I also teach underprivileged children, participate actively in causes I believe in, and travel extensively. The gypsy in me is now at peace – it was a long, unconventional journey, but I would not change a thing.



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The immense beauty of mathematics

R Parimala

I am frequently asked, "Are there other mathematicians in your family?" and the surprising answer, perhaps, is "No".

My father was a professor of English and my mother a housewife. I grew up in an environment where academic performance was the highest priority. My father instilled in me the discipline to work towards excellence in whatever I took up. I studied at Sarada Vidyalaya Girls' High School and Stella Maris College, both in Chennai. I was fortunate to have excellent teachers, both in school and in college, who nurtured my interest in mathematics. When I was due to finish school, my father wanted to know what I wanted to study in college. He suggested medicine or English literature since a career in medicine or in teaching is most suited for girls. Realizing quickly that my interest was in mathematics, he promised to send me to the best possible institution for higher studies.

My ending up with a research career in mathematics was something of an accident. When I finished my M.Sc., I wanted to take up a teaching job at Stella Maris College – a standard career path for many of my seniors who were my role models. In retrospect, I feel that several of them would have been successful math-

emicians, had they been given the opportunity. Miss Thangamani, one of the most revered professors in the college, specifically instructed the college management not to employ me as a lecturer since she felt that I was cut out for a research career! I came to know of this incident much later.

Though I had heard about the famous Tata Institute, I preferred to stay in Chennai to continue my studies. After considering various options, I decided to pursue research studies at the Ramanujan Institute, University of Madras. Professors like Bhanumurthy and Rama taught me mathematics with great enthusiasm. After a year, I moved to the Tata Institute to work with Professor Sridharan for my Ph.D. degree. My thesis title was 'Projective modules over polynomial rings over division rings'. When I finished writing up my thesis, I was diffident about continuing as a research mathematician. The presence of some of the greatest mathematicians of the world at the Institute as well as some brilliant youngsters emerging as shooting stars on the horizon was truly daunting.

At that point, I got married to Raman who was chief internal auditor with the Board of Internal Trade, Tanzania. I took leave from the Institute for a year and accompanied him to Dar-es-Salaam. I had no clear plan for my career. In a few months, Raman took an extraordinary decision. He quit his job to accompany me to E.T.H. Zurich so that I could do post-doctoral work. This critical decision enabled me to get back to mathematics. In Switzerland I met colleagues like M. Ojanguren and M.A. Knus with whom I have had fruitful mathematical interactions throughout my career. To complete my account of my family, my son, Sridhar, has a keen interest in mathematics, and keeps abreast of what I am doing, although he chose for himself a career in technology.

Tata Institute is one of the very few institutes in the world, dedicated to research - it is both a privilege and responsibility to work at such a place. The Institute provides a great environment for research with total academic freedom, an excellent library, and a vibrant visitor's program. Mathematicians from all over the world expose the latest developments through lecture series. I gained a

lot through interaction with visiting mathematicians. Professor Sridharan instilled in me the responsibility of dissemination of knowledge to youngsters. I have had the privilege to interact with students – working with each one of them led to my exposure to new areas. I am proud to say that some of my students have outperformed me.

To sum up, my becoming a career mathematician was a consequence of a series of accidents. Looking back, it has been a highly satisfying profession. I immensely enjoyed interactions with like-minded mathematicians the world over. It is a world of ‘make-believe’, with great excitement from time to time. I only wish I had the lucidity of my father to convey to the outside world the immense beauty of mathematics!



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Way to science

Qamar Rahman

The town is Shahjahanpur, in the year 1950, in an old reputed parda-observing family, a girl of 6 years of age observes her mother being treated at home by a lady doctor. She is very impressed by the physician. She decides to become a doctor. Time passed by and, one day when she was in class IX at Abdullah School, Aligarh, she went to her mother and told her that she wanted to become a doctor. Her mother did not approve the idea; as in her opinion lady doctors discuss certain things with their male patients, which are not very decent. When she was in B.Sc., she got married. Unfortunately, she had problems in her married life and decided that this was not the life she wanted. To live with someone who was so different and did not even respect her, was something she did not and could not accept.

She moved to her parent's house with her daughter who was a few months old. She joined M.Sc. in Physical Chemistry at Saint John's College at Agra where her father was posted as Commissioner. It was quite difficult to study with a child, but her mother helped her a lot with the young baby and she continued her education. After completing her M.Sc. she came back with her parents to Shahjahanpur again.

One day she went to visit her sister in Lucknow and met the Principal of Karamat Husain Muslim Girls College, Ms. Wasim.

Ms. Wasim was looking for a Chemistry lecturer, for intermediate classes.

She joined the college and this was a great experience of her life. Teaching science to young girls, talking about scientists like Perking Senior and Junior, discussing dreams of Kekulé and Fischer's; she used to feel proud. But still she had to do so much more. One day she went to the Department of Biochemistry, at the Lucknow University and met Prof. P.S. Krishnan, a well-known Biochemist, a legend in his field. She requested him to take her for Ph.D under his supervision. First he did not agree but seeing her determination he allowed her to join the department. Soon (1970) Industrial Toxicology Research Center advertised (One of the leading National Laboratory of the Council of Scientific and Industrial Research) a post of Junior Scientific Research Assistant (JSA). She applied for it and got the position. Dr. A.S. Paintal was the chairperson of the selection committee; he said, "You will make a name for yourself in the field."

In her scientific journey she went through various experiences. She realized that at every stage a woman must work harder than a man. It is very difficult for a woman to achieve and make a name in the male-dominated society. But she never accepted defeat and kept herself going in spite of many hurdles. Today, she feels proud of her personal as well as academic achievements. Her daughter is a well-known medical doctor (which was her dream). Her two grandsons inspire her and see the dream to become a scientist.

She has a profound experience in toxicology, a field in which she is working on a wide scale. Her main field of research is the toxicity of fibers, particles and nanoparticles. Based on her work she has published 130 papers in the journals of International repute.

She has worked with the toxicity of silica, asbestos, asbestos substitutes, slate dust, carpet dust, soot and other ultra fine particles, the known environmental and occupational air pollutants which have attracted attention over decades. She has also conducted epidemiological surveys to monitor the impact of these pollutants on the exposed population using biomarkers at molecular level for risk assessment analysis.

Her studies showed that asbestos induce reactive oxygen and reactive nitrogen species. These free radicals activate signaling cascades and cause DNA damage that result in altered gene expression and cellular toxicity important in the pathogenesis of asbestos associated pulmonary diseases. Nanoparticles were evaluated for their toxic potentials. The studies revealed that some of the engineered nanoparticles are toxic and need toxicological evaluation. Pioneered studies on the toxicological effects of slate dust were conducted at Mandsaur and helped in developing diagnostic tests, therapeutic and preventive measures.

She has conducted in depth studies in asbestos based industries both at organized and unorganized sectors and highlighted the predisposing factors existing in Indian industries accelerating the disease processes. The study established that a combination of cigarette smoke and kerosene soot accelerates the disease process in the exposed population. These in-depth studies in asbestos based industries in India highlighted occupationally vulnerable population (domestically exposed to cooking fuels and occupationally to asbestos). These findings are of great national importance to advise asbestos exposed workers to abstain from smoking, avoid exposure to unprocessed cooking fuel.

Surveys were also conducted in a few organized and unorganized carpet units and the factors influencing the health of the exposed workers were determined. She has conducted intensive studies on Indoor Air Pollution due to the exposure of biomass fuels (cooking fuel) in Indian homes. She showed high levels of particulate air pollution due to biomass exposure causing respiratory morbidity and mortality.

She has conducted in depth studies in asbestos mining areas, which includes, monitoring identification of asbestos varieties and complete medical examination along with specific biomarkers for risk assessment. An extensive research on women and their occupational hazards was conducted, highlighting specific problems in different organized and unorganized sectors where women workers are exposed to toxic chemicals (A film on the above subject made by her was selected as the best video film from Govt. of India).

On the basis of the research work on particulate air pollutants and women problems, international and national collaborative projects of great values funded from the United States, Commonwealth Science Council, London, Germany and Government of India, were initiated.

Her scientific achievements were internationally recognized as is visible from invitations she received to pay research visits abroad, to write review articles, to organize international meetings. She has been invited as guest scientist under collaborative programs by internationally known institutions such as the National Center for Toxicological Research Nov. 1981, Cretiel University, Paris, France, 1987 US Environmental Protection Agency, and Duke University, North Carolina, EPA, 94, the US National Institute of Environmental Health Sciences, 1996, German Forschungszentrum Karlsruhe, 1994 and 1996, Institute for Cell Biology and Biosystem Technology University of Rostock, 1998, 1999, 2001, 2002, 2003, 2004, 2005, 2006, 2007 and 2008. She has been invited to give talks and keynote addresses in the national and international conferences. She always took active part in different capacities for the progress of the country in science as well as for the social cause, and for the progress of young scientists.

Now at the age of 63, she dreams of establishing a centre for occupationally venerable population.



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Be not sad a rose bush has thorns; be glad a thorn bush has roses

Hema Ramachandran

People often ask me whether I have found it difficult being a woman in science. If I were to reply without thinking, I would say, “Well, not really”. But then the question could be put differently: “Do you think if certain things had been different, life would have been easier for you as a woman in science?” To that, the answer would be an emphatic “Yes, of course!” In this brief essay, I have tried to convey some of my thoughts and personal experiences related to this topic.

Except for a brief period of four years, I have always studied in co-educational institutions. Being physically well built, I could compete on equal terms with boys in sports, and this, perhaps, enabled me to think of boys (or men) as equals and not as superiors. I find many girls turn shy or embarrassed when they have to make a point or argue with boys; this, I feel, largely arises due to limited exposure to boys, which makes girls think of them as different and perhaps unreasonable creatures. Added to this is the attitude ingrained in them by society, by peers, and by members of the family, that girls should be subdued, calm,

non-aggressive, seen but not heard, and should put others before self.

Right from childhood, my brother and I were encouraged to read a lot, to question, to gather knowledge. My father, himself a scientist and my mother, a housewife – but exceptionally well-read and well-informed – both took pains to teach us. From an early age, there was no doubt in my mind that I would pursue a career in research.

I salute my parents as they were quite different from their brothers and sisters. They brought up their two children – my brother and me – in pretty much the same manner, without discrimination. They never made me feel inferior, nor did they stop me from doing anything because I was a girl. At a time and in a family environment, where girls would be “married off” on graduation, I was encouraged to pursue higher studies, and, more unthinkable, I stayed in a hostel, and in a predominantly male institution at that! After studies, I took up a job, and my parents shielded me from relatives who were aghast that I had taken up a job, and was still unmarried.

While I was often blissfully unaware of discrimination or a biased environment, when I now look back, several instances stand out. One of my earliest memories is of primary school at the age of five or six. It was after a prize-distribution ceremony at the close of term; I had received a few prizes as I had scored the highest marks in several subjects. My friend, a boy, who had stood second in class, was scolded severely by his parents: “Aren’t you ashamed? You have allowed a girl to score more than you!” The import of this did not strike me then, but now when I look back, I wonder how many parents drill into the heads of their impressionable infant sons that they are inherently superior to girls.

The other event that is still fresh in memory is a comment by a close friend of mine, a male classmate in B.Sc., in a college in Mumbai. When I got admission to M.Sc. at I.I.T., Mumbai (and he had not), his spontaneous remark was, “You have spoiled the career of a man. Why do you girls want to study at I.I.T., especially when career has no meaning for women? You have merely wasted a seat in I.I.T. – and deprived a boy of it.” I was shocked by

this viciousness and by the views of a young, educated man from a cosmopolitan background about the inevitable future for a woman.

My first job was at B.A.R.C., Mumbai. I must say that in the scientific field I have not found any serious discrimination by my colleagues. I have found three kinds of male colleagues. The first, usually elderly, tend to make decisions for you: "Oh, it's an out-station conference, how can she go there to present a paper?" I used to bristle at this till I realized that these remarks were well-meaning, protective gestures. Then there are those who intentionally make things difficult, to prove that as a woman I am unable to do certain things. Finally, the younger generation, who have been exposed to increasing female participation in school, college, professional courses, and the workplace. Such persons, especially those with working wives, are more understanding, and tend to treat us more as equals. Fortunately, their tribe is increasing!

A major decision that I had to make was to relocate upon marriage. This was a very difficult decision. It meant that I had to leave an excellent scientific group, and give up a stable job, especially when things were looking very good for me at work. However, I was more worried that I would provide yet another example of the widely prevalent perception that it is unwise to hire a woman employee because she will quit upon marriage, or become irregular when children are born, and that one cannot expect long-term commitment to a job from a woman. Torn between two opposing desires, I finally took the step of quitting my job at B.A.R.C., Mumbai and moving to Bangalore. Fortunately, it so turned out that while I moved out of Mumbai, I did not move out of science. Being of the strong opinion that a woman should be independent, and that no person, man or woman, should be cowed down by others, my husband has constantly encouraged me to pursue my career and not be disturbed by protests that may arise from various quarters. I continued research, although it meant changing my field of study several times. It certainly was not easy. I worked in seismology at Gauribidanur for some time, and then joined the Raman Research Institute to set up an optics laboratory.

Now when I look around, I find that men also switch jobs

although for different reasons; they mainly move on to ones that are more lucrative, or where a career rise seems more likely. Attrition is now the order of the day. What pleases me most now is that often, among young couples, the wife's job is a major consideration in deciding where to settle down.

Life has its ups and downs. A career woman in India has perhaps more downs than ups. But two proverbs have often encouraged me to plough through difficult times – one of these is the title of this essay. The other says that it is darkest before dawn.



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Looking forward to new challenges

Sheela K Ramasesha

When I was a child, my family moved around Karnataka quite often so I ended up attending schools in ten different towns. I studied in different mediums of instruction, but language did not matter for science and maths and I started enjoying them. I was the many teachers' favourite student because they recognized my keenness and ability in these two subjects. This was the catalyst for me to pursue physics, chemistry and maths in college.

During my M.Sc., I chose "Electrical Double Layers" as my seminar topic and I went to the Indian Institute of Science (IISc) library to read up on it. At this time, I got an opportunity to discuss science with a few research scholars at I.I.Sc. who were working in this area. The atmosphere for research and the dedication of the research scholars impressed me greatly. As a novice in science, I had many basic and simple questions, which were answered with patience. I was lucky enough to even be taken on a lab tour! My interest in a research career began to crystallize about this time, with encouragement from my family. This was at a time when girls of my age would have traditionally been married and

not have pursued higher studies. Thus, I joined I.I.Sc. as a research scholar working toward a Ph.D. with the hope of pursuing a research career. My thesis work was in the area of magnetic and electrical properties of perovskite-based ceramics. It was here that I met and married Ramasesha. After completing my Ph.D. degree, I had to decide whether to apply for post-doctoral positions independently of my husband's plans or go with him to a place where he had a fellowship. I took the second option because of my conviction that marriage meant spouses staying together. I followed my husband through his post-doctoral positions and took up opportunities that came to me.

Apart from being a homemaker, I also had the experience of working in newer areas in chemistry; this was to stand by me in good stead during the uncertain years that were to follow after our return to India. The new fields that I was exposed to gave me a unique opportunity to work as a post-doctoral fellow with many highly respected scientists at the University of Oxford, Louisiana State University and Princeton University. I learned the kind of rigor that needs to be put into research work in order to achieve deep understanding of scientific phenomena. I thoroughly enjoyed working with stalwarts of science during my tenure at these universities. My daughter was born during this period, which made our family life more enjoyable.

After returning to India in 1984, career options for me were limited. I could either teach in an undergraduate college with no research facilities or continue taking temporary fellowships. I was also told, "You have a good family, why do you want a regular job? You can't have everything in life"; this upset me quite a bit. Given the independent thinking that I grew up with and a broader outlook in life, I wondered if men had to face a similar situation. I was passionate about having a regular research career and was willing to put in the hours needed without compromising family life. With the support of my family, I decided to continue pursuing research.

I took up a U.G.C. position at National Aerospace Laboratories. Again, this was a difficult decision for me because I had to leave home at 7.30 a.m. and return at 6.30 p.m., with a young

daughter at home. Despite these challenges, I embarked on an independent and productive research career that was to last thirteen years. During the initial years, I worked on the electrical properties of ceramics under pressure. Assembling high-pressure cells was a new experience for me because all the components of the cell had to be perfectly flat and all the electrical and thermocouple leads had to be fitted on a small surface area. Many phase changes of samples, which could barely be detected under ambient pressure experiments became prominent when high-pressure was applied on these samples. Through some collaborative work, I was able to obtain high T_c YBCO single crystals and we measured the Seebeck coefficient not just in the ab-plane but also along the c-axis. The high-pressure set-up was later redesigned to obtain dielectric constants and hysteresis loops of ceramics. At this stage, I decided to build an independent research group and obtained support from DST for a project to work on high-temperature structural ceramics, ceramic matrix/ metal matrix composites. I put together a team of Ph.D., M.Tech and B.Tech students. Working with youngsters was fascinating and refreshing.

When GE started its R&D operations in Bangalore, Luckily, for me, it happened at a time when I was looking for bigger challenges. I was in a secure and pensionable job where my credibility had already been established. Many people warned me against moving into the corporate sector which is rife with challenges and competition. Notwithstanding the naysayers, I applied for a position at the GE John F Welch Technology Center (GE-JFWTC) and embarked on an industrial R&D career.

I started enjoying my work right from the first day. I was the program coordinator for the Solid Oxide Fuel Cells (SOFC), a topic I had never worked on or studied before. It was almost like getting back to school! I went to the library to understand the basics. The SOFC has many metallic parts and we had to develop alloys that performed better than currently known materials. Although my expertise was in ceramics, I moved quickly into metals/alloys and we successfully developed several high performance alloys for SOFC application, for which we were given a management award.

Later, I was promoted as the manager for the Ceramics Synthesis and Processing Lab and nominated for a six-sigma Black-Belt role. As a manager, I had the opportunity to create a vision for the lab, develop and encourage team-members to excel in their work and also bring in new technologies and programmes. All this required both technical and business acumen. We worked on almost all aspects of ceramics. I spent six and a half years here. My career as a scientist has been satisfying. I have eleven U.S. patent applications. I also have about 85 publications and a few awards to my credit.

Looking back, on the whole, life has been good to me. Professionally and personally, I have got everything I ever wanted and am looking forward to all the challenges and newer opportunities that the future holds!



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But for vagaries of Governmental regulations

Mythili Ramaswamy

My early childhood was spent in a small village, Kadayam, in Tirunelveli district, deep inside Tamilnadu. I was lucky enough to have very inspiring mathematics teachers right from my school days. Their encouragement kept up my fascination for that subject. A major turning point was my shifting to Bombay for my college education. My cousin, P.S. Subramanian, was working in the Solid State Electronics group of T.I.F.R. and through him, I came to know about T.I.F.R. and in particular the School of Mathematics.

I was fortunate enough to have very inspiring and encouraging teachers, also in Bombay, both in the B.Sc. at S.I.E.S College, Sion and also in the M.Sc. at Bombay University. An important teacher was Prof. Rangachari of T.I.F.R. who taught us Complex Analysis in M.Sc. He brought out the beauty of that subject in his lectures so well that I started to consider doing research in that subject.

Coming from a traditional background, my first choice after B.Sc. as well as M.Sc. was to look for a clerical job in a bank.

Fortunately I was not able to secure any bank job at that time in Bombay because I did not qualify for a domicile certificate in Maharashtra. The next option was to apply to T.I.F.R. for research. I was selected for the TIFR-IISc joint mathematics programme on Applications of Mathematics, at IISc Bangalore. My parents were very supportive all along and encouraged me to take up research. But for the vagaries of governmental regulations, I might not have been part of the mathematics community!

When I got the INRIA Scholarship to do my thesis in Paris, France my parents although a bit hesitant initially, allowed me to go abroad in spite of the social and family pressures. I had a very fruitful stay in Paris for nearly 3 years. After my thesis, I returned to the Bangalore centre of TIFR. A little later, I spent a year as a post-doctoral at California Institute of Technology, and then returned to the T.I.F.R. Centre, Bangalore, where I am working today, thoroughly enjoying teaching and my research in differential equations.

After my return to India from France, I married Anil Kumar, from the Physics department, IISc. He was supportive and encouraged me, so we both could continue to work hard and also organize our travels within and outside India without much trouble to our little daughter, Vasudha, with my parents' support. I was completely devastated when I lost him recently. It was very difficult for me to come to terms with this loss for quite some time. My daughter, parents, students and friends have helped me to get back to life, and I am here once again enjoying my work.



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Building a new discipline

Jayashree Ramadas

I was born in Mumbai in 1954 and first went to St. Thomas' School in Delhi. My earliest "aha!" memory is when in Montessori school I was smitten by a set of shining golden unit beads, in rows of ten strung on a wire, ten perfect squares of a hundred, and one cube of a thousand glittering beads. I was extremely privileged, for, experiences of hands-on exploration are all too rare in Indian schools. Beautifully crafted equipment might come expensive, but even simple resources available locally are spurned in favour of rote learning from dry texts.

My other pleasant memory is when Ms. Wilson, our English teacher, got us to write rhymes and limericks. In our final exam, we had to construct a limerick, which I enjoyed greatly. At home we spoke Marathi, and my mother passed on to me her love of colloquial language and playful idiom. All of these came together in my later work with primary science teaching.

Grade seven was at the American School in Baghdad, where my father, a telecommunications engineer, was posted on a U.N. assignment. My parents held that this school opened up my interest in academics, but I recall it as a year of profound adolescent angst and anxiety. Among physically strong, sexually aware and racially confident kids, the only time I felt welcome was in the

weekly mental math event, when all of the students vied for me to be on their team. Our science and math teacher Mr. Berndt got us to do a lot of project work which I enjoyed.

When the American School closed down after the six-day Arab–Israeli War my mother brought me back and got me admitted to St. Helena's boarding school in Pune. Here, I found good science and math teachers, Ms. Joseph and Mr. Jog, and an interesting textbook of physics, by Gregory, Dhond and Ingle. Learning was dependent on reading a single textbook, with some rare demos – I remember an astounding one in which a little water was boiled in a ten-litre empty kerosene can which, on capping and cooling, loudly and spectacularly crumpled into a heap.

I loved physics and I was intrigued by psychology - partly due to the influence of my paternal aunt who was in social work. So after completing school I considered both science and arts, and opted for science at Fergusson College, Pune. Though biology was traumatic, I greatly enjoyed solid geometry taught by the very disorganised Mr. Inamdar, with a book by Wrangler Mahajani. Mr. Pathak, who taught chemistry, once gave a memorable home assignment to draw the structures of some linear hydrocarbons, into which list he smuggled the formula C_6H_6 . Innocent of aromatic compounds, the pleasure that I got in figuring out the structure of benzene remained with me for years.

At the Indian Institute of Technology, Kanpur, Profs A. P. Shukla, H.S. Mani and others taught us wonderful physics, yet in those years I felt accelerated beyond my capacity. The summer after M. Sc. I made up for this, with a leisurely reading of the Berkeley Series on Electricity and Magnetism by Purcell. In college I used to look critically at the textbooks and tell my friends that one day I would write better ones. My interest in science, psychology and pedagogy came together when in 1976 I joined the Homi Bhabha Centre for Science Education, T.I.F.R.

Since mine was probably the first thesis in science education in India, I had to go through a slow process of defining the field based on information I came across in print. I was fortunate being at H.B.C.S.E. surrounded by the research at T.I.F.R., to have access to resources that would have been impossible elsewhere

in the country; and isolation from international research trends left me free to follow my own interests.

H.B.C.S.E. gave me a view of school science from the top – with a state-wide survey of schools and teachers – and from the bottom – sifting through and analysing a few hundred science lessons in rural schools in Jalgaon district of Maharashtra, and weekends teaching in a Bombay slum. This and later work in the Nonformal Education Programme of the Indian Institute of Education in Pune made me realise how rich were the experiences of rural children in their natural environment, and how completely wasted they were in the formal structure of the school and the curriculum. Prof. V. G. Kulkarni, founder-director of H.B.C.S.E., used to emphasise the role of language in science learning; much later I understood the significance of his remarks. Language being inseparable from thought, our failure to develop basic literacy and numeracy is intimately connected with the culture of rote-learning that is the bane of our school science.

As a struggling graduate student thrust into the role of teacher-educator at H.B.C.S.E., I got interested in students' ways of thinking about science concepts, because I could teach the teachers something they could directly apply in their classroom. Around the same time, such investigations were going on elsewhere too, and their results were named "students' alternative conceptions". I learnt more about this field during post-doctoral work at Leeds with Prof. Rosalind Driver and at Chelsea College with Prof. Paul Black and others.

Some years later I was stimulated by the intellectual ambience that Prof. Seymour Papert created at the Massachusetts Institute of Technology with young engineers, computer scientists and psychologists, along with artists and designers, at the Learning and Epistemology Group in the Media Lab. In U.K. and the U.S., I worked in rural and inner-city schools, one of which was fitted with a metal-detector at the entrance. This was quite an experience. My interest in children's conceptions and their understanding of diagrams was sustained by these interactions.

A peer group was lacking, in India and internationally. That has been my major difficulty in doing science education re-

search. Due to a lack of critical mass, research at H.B.C.S.E. remained a low priority for many years. In the 1990s, the Centre Director Prof. Arvind Kumar advised me to take up curriculum development, a decision that I have never regretted. It was a unique opportunity to develop a curriculum based on research and field work, unconstrained by syllabus requirements. Teachers' and parents' warm appreciation has more than sustained the effort.

In the meanwhile, a core research group has emerged at H.B.C.S.E. I believe that a healthy interaction between research, curriculum and practice will enable it to grow. My early work on students' drawings and schematic diagrams finds resonance with current research – in developmental psychology, cognitive science, history of science and science education – on visual-spatial models of understanding science. I anticipate more action here. The epiSTEME series of conferences started by H.B.C.S.E. helps create links across the country as well as internationally. H.B.C.S.E.'s primary science curriculum is known and cited in India and abroad. My personal struggles in this have been closely tied with institutional struggles and those of a new research discipline.

I could not have done without the contribution of two other women: Mrs. Bapat, herself the wife of a scientist, who affectionately looked after our two children, and Kala, a highly capable woman who gave up her own childhood to work as a domestic help in the T.I.F.R. colony. And yes, my husband and children have definitely helped sustain me in my career.

Do I now wish I had done anything differently? First, as a school and college student I ought to have actively sought out good books instead of depending on what was handed over to me. Second, early on, I might have taken the trouble to learn to express myself coherently in speech – something that a science student is rarely taught to do. Third, as a junior researcher I might have cultivated more harmonious relationships with my bosses. I however, realize that some aspects of personality are hard to change. Fourth, I should have been proactive in dealing with child labour, a callous practice that still keeps the majority of our girls and boys from achieving their potential.



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An austere beauty

Sujatha Ramdorai

The response of people, when they learn that I am a career mathematician has long been one of the following: “How fascinating, I have always loved mathematics and used to be quite good at it in my school years”; or “That was the subject I feared and hated most, how can someone be doing mathematics all of one’s life?” After the commercial success of John Nash’s life story, there is a third response: “Interesting, I saw the movie ‘A beautiful mind’, it is about a mathematician who was slightly crazy, and I loved it.” It is often difficult, at a social level, to convey the pleasure of a life-long fascination with knowledge, and even more so when it is mathematical knowledge!

There was no academician in my immediate family but I was fortunate to be born in a family which revered education and knowledge. My attitude to academics was shaped by my grandmother, who all through her life lamented the fact that she was not fortunate enough to have had a full education. Her thirst for learning and knowledge however stayed with her all her life and she instilled it in me and my brother. I grew up being hardly conscious of a life beyond one that encompassed the mind.

I was born and brought up in Bangalore which is home to one of the premier Science institutes in the country. I was competitive

in my school years and was indeed lucky to have had teachers who were very dedicated during my high school years. My love for mathematics started early on in my primary school, when I realised that one could do well in this subject by just understanding it! Among my happy memories of the summer vacations are those that I spent in the city library reading and also of the times when we got the text books for the next year. I would quickly try to understand and work through the early math chapters before school started. The other subject we would run through much faster and more easily was english.

In the late 1970's, there was no career counselling and information was not as freely available or accessible as it now is. Engineering was not the rage that it is now. However, it was clear that a successful degree in a good engineering college, preferably in computer science, meant that one's career was comfortably made! There were not many women doing engineering and I was torn between pursuing a degree in the pure sciences and an engineering degree! When I was discussing this with one of my seniors in my pre-university years, he asked me if I liked abstract thinking. I said I loved it and then his immediate response was that I should then continue to do mathematics rather than engineering! This helped me make up my mind and I did not even apply to any of the engineering or medical colleges after my pre-university results were out. I still remember that many of my classmates and friends thought I was crazy, especially as securing admission in the best professional colleges would have been trivial.

I got married before I graduated and then continued to do my Master's degree in mathematics, by correspondence. I was still unaware that a research career in mathematics was possible, the level of information dissemination was quite abysmal then even in cities! We moved to Bombay and here a few people vaguely mentioned 'Tata Institute of fundamental Research', however knowing little beyond the name! It was a sheer stroke of luck that I chanced upon the advertisement of TIFR calling for admissions to the Ph.D degree... I did my Ph.D there under the supervision of Professor Parimala Raman and have continued to work there after my Ph.D.

My thesis subject was the algebraic theory of quadratic forms over fields; an area with connections to various other fields in pure mathematics. But in the last decade, I have been working in the area of arithmetic geometry, especially that of elliptic curves. Elliptic curves are very special, with an enormously rich structure, multi-layered, with connections to complex geometry, topology and number theory. From the number theoretic point of view, they are greatly fascinating, being the mysterious arena in which there is so much intrinsic structure, yet with many deep conjectures and open problems! Of course, these days elliptic curves are rather fashionable because of their applications to cryptography, but their study goes back to a few centuries! How can one convey the purity of structure and the accompanying beauty that one encounters as mathematical problems yield themselves to solutions? The following quotation from Bertrand Russell comes to mind:

“Mathematics, rightly viewed, possesses not only truth, but supreme beauty – a beauty cold and austere, like that of sculpture, without appeal to any part of our weaker nature, without the gorgeous trappings of painting or music, yet sublimely pure, and capable of a stern perfection such as only the greatest art can show.”

Mathematics underpins many of the research in the Sciences and also much of the technology. Yet I think that scientists in general, and mathematicians in particular, are not good at promoting their subjects or in conveying the excitement of research! Many bright young students in India get sucked into the Information Technology madness, and perhaps feel frustrated after a few years when they discover that their minds are not challenged enough! The intellectual freedom that academics have is something very valuable. Of course, with it comes the responsibility, frustrations etc, but the challenge, should we seek it, is there, beckoning us constantly. Patience, discipline and rigour, especially in mathematics, are essential in a scientific career. Often, one can spend frustrating days and weeks not seeing the path to solve a problem. When one finally sees it, that joy and the eventual beauty of all parts of the intellectual puzzle fitting together so intrinsically, makes one feel that it was worth all the periods of frustration!

Another invaluable facet of an academic career is the

collaborative component. It is deeply rewarding to be able to share ideas with other researchers from around the world and work together. Both at a professional level and at a personal level, such experiences enrich our lives and bring people together in a manner that is becoming more and more rare in other areas in today's strife-torn world!

Finally, I want to say a few words about being a woman in Science. When the Harvard controversy erupted few years back (the President of Harvard university is supposed to have made some comments about women being unsuitable for Science), the accompanying discourse rarely touched upon the fact that Society is not yet fully ready for women to be in Science! I am very conscious that in India, women have multiple contextual roles to play, and am also constantly struck by the fact that women do it with dexterity and ease, across sections of society! For women, a scientific career perhaps offers more flexibility in combining a career with a family life. Scientific policies could be shaped towards making them sensitive to the problems of women. I truly feel that there is a whole new world in science waiting to be discovered and claimed by women.



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Overcoming fear and forging ahead

Sumathi Rao

Why did I choose to be a physicist?

I was a very good student in my school and college days, and was always interested in puzzles, whether verbal or numerical. As a child, I loved detective stories. I enjoyed maths and science, both of which seemed to be based on deductive logic. As I grew up (in Vadodara), I started reading books on popular science and scientists and wanted to become a scientist.

My father encouraged us to aim for the top: the minute I announced that I wanted to be a scientist, he decided that I would be like Marie Curie. My mother's ambitions were more down-to-earth and realistic. She herself would have loved to study, so the idea of my being a scientist and hence a life-long student found immediate favour with her. She thought of it less as a career and more as a passion that one could combine with family life.

However, I was not just fond of science, I had very strong feminist views and career ambitions and, in fact, at the school leaving stage, I thought hard about whether it was a good career

choice, or whether engineering would be a better option. (I hated medicine!) I was also worried that doing science would be considered less prestigious for someone who was a 'topper' and who had got admission into the more prestigious lines like medicine and engineering, including I.I.T. Securing the National Science Talent Scholarship (NSTS) was actually what made me follow my heart, since it differentiated me from the others who were doing physics because they could not get into the professional streams.

The NSTS summer schools also enabled me to meet other young students of my age interested in science. This was not true in my peer group at school (a girls' school). This was an eye-opener to me and it was fun to meet other students who also wanted to discuss problems in physics. This enjoyment continued later at the Indian Institute of Technology, Mumbai, where, despite the pressures of tests and exams, I remember that studying physics was a lot of fun.

Stonybrook where I did my Ph.D. was also more of the same. We had a wonderful peer group where we learnt a lot of physics and a lot about life from one another. I did my Ph.D. in high energy physics, in the sub-field of grand unified theories, which seemed really exciting in those days. I had a reasonably good rapport with my Ph.D. advisor, who was quite young, and did not have any bias against a woman student, although he was pretty worried when I came back to India for a long break in my first year; he thought that I would get married and drop out!. But my real mentors were my fellow students; we all inspired, tested and taught each other!

The major obstacles in life came as we grew older and had to look for jobs. I got married to a fellow student at Stonybrook and both of us took post-doctoral fellowships. My first post-doctoral fellowship was together with him, but after that it was difficult to get jobs together. We used to discuss physics in the early years of our marriage, since that was one of our common interests and partly what had brought us together, but I had to be careful to work independently, so that I could be judged independently.

We both wished to return to India, and did not look for jobs abroad. But in those days (the mid-to-late eighties), there

were not too many institutes in India, and not too many jobs. There were archaic, unwritten, anti-nepotism rules which prevented a husband and wife from having jobs in the same place. I got a job at the Institute of Physics in Bhubaneswar and my husband got a job at the Tata Institute in Mumbai, at two opposite ends of India. We were both career-oriented, so the choice between staying together and staying apart to take up jobs at two different places was not hard to make. I must add that I have had an exceptionally supportive family. My in-laws, in particular, never made me feel guilty for making this choice.

However, having made the choice, life was not easy. Communication was difficult in those days. Neither of us had phones and the Information Technology era of emails and internet was still in the future. So was cheap air travel. Trains between the two cities took about 40 hours. Besides living apart from my husband, even living alone in the small town that Bhubaneswar was in those days was not easy. I finally ended up staying in a guesthouse room on campus, and living a Ph.D. student's life, ten years after I had got my Ph.D.!

This was when I also realised that it is hard for a young woman faculty member to be taken seriously by students and post-doctoral fellows who are close to her in age. Besides the kind of attention that a 'single woman' (and young married women living apart also fall in this category!) attracts, young women physicists are constantly being tested. Not having a loud voice or an aggressive personality is confused with lacking confidence in one's work.

Finally, when I found that my achievements were belittled, and my work and papers attributed to my husband, I made a crucial decision to shift my field of research so that my husband and I would not be in the same field. This essentially made life more difficult for me, since a lot of my training in high energy physics and contacts abroad would no longer be useful and I would have to start all over again.

In the long run, I think this was a good decision. Condensed matter physics is a wide field with a lot of interesting problems and my earlier training has not gone to waste. Also, it has enabled me to get good Ph.D. students - I am grateful to my first

Ph.D. student, who was smart enough to be unbiased - and they have definitely helped in keeping me enthused about physics. Finally, eight years after we returned to India, and twelve years after our marriage, both my husband and I found jobs at the Harish-Chandra Research Institute, in Allahabad in 1995. We are now well settled and are both senior faculty. Over the years, besides research and teaching (which I enjoy), I have also started working on the question of women in physics, and the subtle biases that force out many highly talented women from the job market.

If I had to restart my career now, would I still choose physics? Definitely, yes. I still feel that it is one of the most logical subjects and teaches one to think about everything under the sun. Finally what would I do differently if I had to start all over again? I would be far less sensitive to the comments which hurt me as a young woman. I would be less afraid of working on what I liked, less afraid of making mistakes, and less afraid *per se*! But perhaps this is something only a senior woman can say. Other than that, I guess I am quite content with life as a physicist in India and wouldn't trade it for any other profession! Which other profession allows us so much freedom? In which other career does one feel part of an international community? In which other career can one visit so many different countries for seminars, collaborations and conferences, and get to know at least the physicists from that country?



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Follow your heart

Renuka Ravindran

I went to a very ordinary school – the Presentation Convent, in Vepery, Madras (now Chennai). The Anglo-Indian High School syllabus at that time allowed one to choose special subjects for the class twelve examination. I chose geometry and trigonometry. Our teacher had just rejoined work after taking leave for over ten years to raise a family. She used to struggle to solve the problems in Loney, the text prescribed for trigonometry. These were delightful problems from the Tripos examination. Whenever she was unable to solve a problem, she would say, “Let us ask Renuka to do it.” That was enough to send me into a tizzy, working for hours until I had solved the problem.

More than school, though, it was the environment at home that was exciting. At the dining table, the topics of conversation were usually about why heavier-than-air bodies could fly or whether the period of a simple pendulum depended on the weight of the bob or what the special features of diesel engines are. This was a time before television had invaded homes. Since my father could quote pages of poetry, we children would spend entire vacations learning the 75 verses of Fitzgerald’s translation of “Omar Khayyam” or Browning’s “The Pied Piper of Hamelin”. We read a lot of classics, including D.H. Lawrence and the Bronte sisters. I

am glad that I was exposed to subjects other than mathematics – in fact, the B.Sc. syllabus of Madras University required us to do two minor subjects from the Arts – I chose politics and philosophy.

When I joined the Indian Institute of Science as a research student, the major influence on me was that of my research guide, Prof. P. L. Bhatnagar. He was a towering personality in every sense of the word – academically and physically. He had a passionate fondness for mathematics as a whole and it was easy to imbibe that from him. His work was everything to him; he worked round the clock and thought, lived and dreamt mathematics. He had undergone spinal surgery and could hardly walk, but that did not stop him from giving lectures. He always remarked that if one did not find the topic of one's own lectures interesting and exciting, how could one expect students to listen and learn from it. His enthusiasm was infectious.

Once I joined the faculty at I.I.Sc., there were many occasions to interact with scientists from all over the world. From being a student, I slowly graduated to teaching and guiding others. Teaching has always been a pleasant task.

What is it that made me take up a career in science, when the family had a tradition of appearing for competitive examinations and going into government service? I can only say that from my early school days I had a passionate fondness for mathematics. Here was an area where the proofs were precise and unambiguous. There was clarity and precision at every step. What could be more enchanting!

As a woman, has it been easy to pursue a career in science? I have never felt disadvantaged just because I am a woman. I had family backing and support and a most encouraging husband. Certainly, it was not easy to have a wife who spent years abroad, who was not at home very often, who was not a traditional housewife. How many men are willing to acknowledge that a woman's career is as important as their own? Of course times have changed now, but forty years ago, it required a lot of understanding and I am ever grateful for that.

If I were asked for a few words to young women setting

out on a career in science, I would say “Follow your heart. If you are convinced that you must take up a research career in science, do so. Otherwise, there are many other options open to today’s young woman.”



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Good mentors and role models

Vijayalakshmi Ravindranath

To me there cannot be a more noble profession than being a scientist. Each day is a challenge bringing with it inevitably something new and novel. In my student years I looked forward to my day in the laboratory, the challenge of the experiment, the day that brought with it both disappointment and the joy of success. Today, as a teacher and researcher, I look forward to my day with my students. They are my inspiration and bring immense joy to my life. Watching them grow and mature as scientists is in itself a reward for me.

My father has had a great influence in my life. He instilled the value of hard work, strive for excellence, and the importance of integrity and honesty. He believed that education was essential for women, and that it would prove to be more valuable than inherited wealth. He encouraged me to study science much against the wishes of the elders in the family who were very keen to get me married immediately after graduation. My parents' support helped me complete the master's degree in Chemistry. I joined for research at the Indian Institute of Science, where I met my husband Dr. B. Ravindranath who is also a scientist. I have been fortunate; my husband has been my best friend and mentor and

provided me immense support all through. Any success that is attributed to me is because of his support and encouragement. He has always advised me to stand up for what I believed in and not to ever compromise on the fundamental principles of my life. I have followed this advice and his support has provided me the strength to do so. I have also been fortunate to have had good mentors, who have been my role models. My Ph.D supervisor, Dr. Raghavendra Rao (at CFTRI, Mysore) and Dr. Michael Boyd, my mentor during the post-doctoral fellowship at NIH, USA have always supported and encouraged me. After my return from USA, the initial years of my independent scientific career as an associate professor at NIMHANS were very difficult. It was very hard to get funding for research and I also felt very isolated. It was at this time that Dr. Boyd helped me tremendously. We collaborated and wrote grant proposals and he provided support both intellectually and in terms of resource that not only ensured that research went well but also critically provided me the platform for interaction with my peers internationally. The journey has never been easy, nor is it easier now. I had to be separated from my family during the post-doctoral years. Now again, when I took up the task to establish NBRC, I have been away from my family and have been commuting between Delhi and Bangalore for nearly a decade. It is only the support system and the network of friends, family and mentors who have provided me the strength to overcome and march on. As I often tell my students, one has to become like a rubber ball; the harder you hit it – the higher it bounces.

At a time when the enrollment in science is low and there is a dire need for teachers and researchers in academia, it is to our benefit to make the workplace gender friendly by including more women in decision-making processes. Although there may be an equal numbers of men and women enrolled in science, the number of women who make it to higher positions dramatically falls. Even if we take into account the drop-out rate of women from the work force due to personal reasons, *the glass ceiling* makes it very difficult for women to move into higher positions.

One of the most critical things that are necessary for building a successful science career is having a support system and

mentorship. While both these are necessary probably throughout our professional life, it is most significant when we start out our research career. Women scientists particularly need help and support to tide over the early period of marriage and child rearing when they are struggling to balance their early career with a growing family. As a minority in the work environment and between managing two jobs - (home and the work place) - women scientists lack the time required to network with peers and build a support system, where one can share both triumphs and disappointments, (the latter constituting a big part of a scientist's life!) It is important that women scientists develop a support system, and this can happen only if women scientists network together and support and help each other. The other important aspect is mentorship. I have benefited tremendously from this and my mentors have supported me and helped me through most of my research career over the last fifteen years, and I look forward to helping create a new generation of empowered scientists, who will be known as scientists who happen to be women, but not women scientists.



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My career in medical research

S Sandhyamani

I was very lucky to be educated without interruption in my studies unlike my mother, Pushpa, and be the first lady doctor from my family. My father, Dr. Sriramachari, who specialized in Pathology, became a medical research worker of repute and continued active research till the age of 84 till his sad demise. I had the privilege of learning my alphabets from Master N. Sitaramayya, who taught Sir C.V. Raman during his school days.

My earliest recollections of my father's lab in Nutrition Research Laboratories, Coonoor were of the smell of formalin, alcohol and xylene, the microscope, and experimental animals. My father introduced me to the fascinating and fantastic world of microscopy. Besides his work on nutritional liver diseases and later, neuropathology, he was deeply involved in research on polarization microscopy and photomicrography. I was so awestruck by his knowledge of physics and chemistry that I developed diffidence for these two subjects. However, I always wanted to emulate my father. Along with my father's advice, my maternal grandfather's astrological prediction that I would take up medical research linked to my father's work, also helped me take the decision to pursue a career in medical research. I studied MBBS at Maulana Azad

Medical College, New Delhi; I chose to do postgraduation in Pathology.

As a postgraduate student at All India Institute of Medical Sciences (AIIMS), New Delhi, I had the unique opportunity of learning pathology from my teachers in the Pathology Department and from my father, Director, Institute of Pathology. Postgraduation at the Pathology Department at AIIMS, was a very exacting and intense course of two years that shaped us into sound, all-round pathologists. There were no didactic lectures and we were expected to absorb and acquire knowledge through routine work. Research was just woven into it. Together with my father, I developed a better fat-staining technique and an improved recolorization technique for museum specimens, later published in the oldest pathology journal 'Virchows Archive'.

Within six months of starting my postgraduation, there was a major catastrophe in our family. My mother suddenly died of a medical accident. It was my father who advised me against having a break in my studies and who helped me cope with the demands of departmental work and duties as well as managing the house. I learnt from him that immersing oneself in research was an important way for de-stressing.

After working as a Senior Resident and Research Associate in the Pathology Department at AIIMS, I was reluctant to get married and leave Delhi. After a lot of persuasion by my father, I married Alwan, a chemical engineer at the Vikram Sarabhai Space Centre, Trivandrum, Kerala. I joined the Sree Chitra Tirunal Institute for Medical Sciences and Technology (SCTIMST), Trivandrum, as a Lecturer in the Department of Pathology. While conducting autopsies, I identified a new vascular disorder in young individuals, which I named "Mucoid Vasculopathy". Affected blood vessels were narrow, resembling rubber tubes and blocked by blood clots and mucoid plaques rather than fat and cholesterol as seen in atherosclerosis. Using low-protein high-starch diets similar to what was eaten by the patients, I developed a monkey model, which conclusively showed that such nutritional imbalances were indeed responsible for this condition, changes in other organs, biochemical parameters and associated type of metabolic syndrome.

Incidentally, this monkey model was an extension of primate experiments using protein deficiency carried out by my father in 1957. My recent studies have revived the pathology of rheumatic heart disease proposed by earlier pathologists, which was forgotten in the last fifty years. I have now embarked on a detailed study on rheumatic heart disease and on toxico-nutritional or lifestyle-related diseases at my institute.

My studies on patients and the monkey model thus helped me to define four important areas of work pertaining to nutritional disorders: vascular diseases, endomyocardial fibrosis, rheumatic heart disease and diabetes mellitus of different forms.

Louis Pasteur said, "Chance favours the prepared mind." I am grateful to all my teachers, especially, (late) Dr. H.D. Tandon, former Director AIIMS and Head, Department of Pathology, for the excellent training I received. My work was well appreciated by senior pathologists from India and abroad, such as (late) Dr. Suman Kinare, Dr. B.N. Dutta, Dr. Prem Chopra, Dr. M. Balaraman Nair, (late) Dr. C.W.M. Adams and Dr. Malcolm D. Silver.

Dr. G.B. Parulkar, (retired) Cardiovascular and Thoracic Surgeon, KEM Hospital, Mumbai, introduced my work to the international arena at the World Congress of the International Union of Angiology held in Paris in 1992, where I received the 2nd IUA prize for my monkey model for mucoid vasculopathy and associated heart and endocrine organ changes. This was followed by a series of national awards and one from my institute. My work was published in a number of international journals of repute, many as single author publications. I am extremely grateful to Dr. B.G. Harigopal, Advisor, DST, New Delhi, for smooth coordination of my two projects on mucoid vasculopathy and the monkey model. My project team with Ms. Vijayakumari and animal handlers worked tirelessly to look after the experimental monkeys.

When I discovered mucoid vasculopathy and associated conditions in the autopsies, I had to face considerable skepticism from some of my professional colleagues. My monkey model drew intense ridicule, derision and criticism from some of my peers and fellow pathologists. The intensity of such reaction was directly

proportional to the importance of my work, my results and the acclaim I received. I was, therefore, delighted to learn from the pathologists from Uganda and South Africa that the disease patterns in their countries were indeed identical to those encountered by me in Kerala. My greatest moment was when I received a letter from Dr. J.N.P. Davies who had studied the effects of severe forms of malnutrition in Ugandan children and discovered endomyocardial fibrosis in the middle of the last century. He concurred with all my findings in the human disease and the monkey model.

I was the first Asian and only woman scientist after 30 years of the apartheid era to deliver the Bunny Becker Memorial Lecture in South Africa on invitation by Dr. Kum Cooper. There is a famous Sanskrit *shloka* I learnt in school, “*vidwatwam cha nripathwam cha naiva tulye kadachana, swadeshe poojyate raja, vidwan sarvatra poojyate*” (A king and a scholar cannot be compared, the king is worshiped only in his country, the scholar is revered all over the world).

My father who passed away recently, had always been a role model for me, giving advice on how to cope with the adversities and lean periods in ones work and sharing the excitement of each “bright idea.” My husband gave me tremendous encouragement in my research work and moral support during crises. My elder son, Aravind is an engineer, doing Ph.D. in nanotechnology in USA. My younger son, Anand, has just entered medical college. I was very lucky to have good domestic help throughout my career. I received immense encouragement from Dr. M.S. Valiathan and Dr. K. Mohandas, former Directors, SCTIMST, and my well-wishers. I am very grateful to the horde of skeptics, without them my hunger for scientific discovery would not have been stimulated.



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A complete woman

Chitra Sarkar

I was lucky to be born in a middle class family which prioritized academic excellence. I was an only child, and my father treated me like a son in the way he encouraged my education, while my mother ensured that I also developed the skills I would need later as a wife and mother. It was in high school that I realized that mathematics was not my cup of tea. Hence I switched to biology and that paved the way for my entry into medical sciences. Study in medical school was also made possible because the government of India awarded me a merit scholarship for academic excellence.

After I completed my M.B.B.S from Bangalore Medical College, my parents, especially my father, encouraged me to do an M.D. It was at this stage that I had to decide on a subject of specialization. Ultimately, after a lot of debate, I chose pathology because it was the subject with the best blend of clinical and basic sciences and which helped me understand cause-effect relationships in health and disease. Also, since it did not involve heavy night duties, it would help me to look after my family. It was my father's dream for me to pursue post-graduate studies at the All India Institute of Medical Sciences (AIIMS), the premier medical institute in India. Destiny had a great hand in fulfilling my father's

dream and in getting me my subject of choice. In July 1978, in the All India entrance, I was selected at AIIMS in the Department of Pathology.

It was here that I first got introduced to research, since the M.D. degree here had a thesis component. Again, I was extremely lucky to have four very encouraging and noble teachers, viz. Prof. Subimal Roy and Prof. N.C. Nayak from Pathology and Prof. P. N. Tandon and Prof. A.K. Banerji and Neurosurgery, who are responsible for my career today in neuropathology, a subspeciality of pathology that deals with diseases of the brain, spinal cord, muscle and nerves. The other great influence was that of Prof. P.L. Lantos, Head of Neuropathology at the Institute of Psychiatry, London, a doyen in his field, under whom I did my fellowship in neuropathology.

After completing my residency and fellowship programmes, I joined as faculty in the Dept. of Pathology at AIIMS and since 1998, I have been Professor of Pathology as well as Chief of the Neuropathology Division. What I have enjoyed most about this job is that it enables me to see patients, teach students and also pursue research; hence there is no monotony. Clinical medicine gives me a lot of satisfaction when I see my patients getting cured. Teaching and interaction with my students has helped keep me young. However, it is the research component which gives me the greatest pleasure because it allows me to translate new bench innovations to the patient's bedside. Research in medical sciences in India is still in its infancy and there are very few doctors who pursue research. Clinical research is very challenging and there are many opportunities in India not only because of the large numbers of people but also because of the wide variety and unique diseases endemic to our country.

During these years, I got married and had a daughter. My parents also stay with me. Most women feel that family responsibilities are a hindrance to professional progress. But I feel I have progressed only because of family support and encouragement, first from my parents, then my husband and finally my daughter who never complained about the time that my profession demanded. Also my teachers, and mentors' continued encourage-

ment and their faith in my competence helped me through several stressful periods of my career and sustained my interest in neuropathology. Further, it was the successful research experience I had at a relatively young age coupled with joy of seeing my name in print and my papers quoted in leading textbooks of medicine as well as receiving numerous prestigious awards that helped me sustain my research career.

I am happy that I have been able to accomplish everything in life as a complete woman in different roles – daughter, wife, mother, teacher, doctor and researcher. I feel I am blessed and would do nothing different in life if asked to do it all over again.



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Dharmo rakshati rakshitaha

G V Satyavati

*“Two roads diverged in a wood, and I...took the one less traveled by,
and that made all the difference.”*

— Robert Frost

I grew up as a shy, lonely girl in a middle class Brahmin family with seven male siblings. I obtained a high rank in high school and intermediate examinations in Science and Mathematics, but was not able to get admission to Medical College, Mysore, due to my selection of wrong subject combination (Physics, Chemistry, Mathematics, instead of Life Sciences), as also perhaps because of my gender and community!

A chance meeting of my father, a practising doctor, with Prof. C. Dwarakanath, Principal, Government College of Indian Medicine, Mysore, led to my admission to this college. The syllabus integrated vital elements of Ayurveda and western medicine, along with an advanced course in Modern Science (supervised by Prof. Seebiah, a renowned physicist) and my first two years in this college ingrained the spirit of scientific enquiry, and kindled hopes of research. As a topper in the final year, I got automatic admission to the MBBS course at the Mysore Medical College. MBBS degree was totally examination oriented and gave me good clinical

experience but failed to provide any foundation for research!. The 1960's were a time of open gender bias. As one of the few girls riding a bicycle to college in Mysore city, for years I was subjected to teasing, abuse and even physical assault on the road by male students of other colleges and hooligans. When an examiner asked me my idol in science, "Marie Curie" was my prompt reply. His reaction was "Marie Curie did nothing but help her husband; how can she be your idol?" I must say that this was my first taste of male chauvinism. My desire to pursue further studies met with vehement opposition from my family and well-wishers: "Why does a "lady doctor" choose not to practise or accept a teaching job in subjects like Obstetrics & Gynaecology, Paediatrics, General Medicine etc? What is this wonderful research the girl can do in India?"

My father somehow yielded to my determination and Prof. Dwarakanath's persuasion, and allowed me to proceed to Banaras Hindu University (BHU), Varanasi, for advanced studies in 1964. The next five years at BHU saw me developing as a researcher. BHU offered a highly academic environment with excellent facilities for research, but the general atmosphere was not friendly for a young, single female researcher. A single, working woman was highly vulnerable to sexual harassment, and although I faced petty jealousy, malice and general hostility from some male faculty, my determination and the remote moral support of Prof. Dwarakanath in Delhi, Prof. K. N. Udupa, Varanasi and a few other local colleagues helped me through the first two years. My hard work at BHU resulted in two independent doctorates in two different systems of medicine, (along with valuable lessons on survival as a single working woman, in a man's world!). My first doctorate in Ayurveda, involving pioneering work on the discovery of lipid-lowering effect of Gum guggul, brought me national and international recognition. My second doctorate in Pharmacology obtained while working on an ICMR project post under the Composite Drug Research Scheme (CDRS) helped me acquire advanced knowledge and skill in experimental pharmacology and drug research. I also met here my future husband Dr. D. N. Prasad, who was the guide for my doctorate thesis in pharmacology.

I joined ICMR Delhi, as a Senior Research Officer (1969) and had rewarding experience in assisting Prof. Dwarakanath in monitoring national scale research on herbal drugs. The transfer of CDRS (along with funding) to the newly created CCRIMH (in Health Ministry) forced me to choose ICMR for its vibrant scientific ambience and autonomy.

From 1969 to 1986, under three successive directors-general at ICMR who were inspiring leaders, I was entrusted with major research and managerial responsibilities. I grew from a young researcher to a mature scientist and research coordinator, with wide exposure to central planning, policy making, designing, executing and reviewing, monitoring medical research. With scientific autonomy and encouragement and opportunities for creative work, I feel that 1971–1987 were my golden years at ICMR. However, like all workoholic women professionals, I had to struggle throughout, balancing career with domestic responsibilities.

The chief editorship of the Indian Journal of Medical Research for 18 years and two encyclopedic volumes on Medicinal Plants of India (edited by me and published in 1976, 1987) brought satisfaction and accolades, as did major HRD activities in biomedical research, organised by me. Since 1970's, my expertise on herbal drug research was in demand (in India and abroad). In 1985-86, I had the satisfaction of launching large scale national projects on herbal drugs with a disease-oriented approach.

In 1994, I was appointed Director General of the ICMR (till 1997). This is a coveted post for all medical scientists and while the appointment, of the first “woman DG” was hailed in media, in some ways this turned out to be an ordeal due to a set of adverse circumstances. Although I had support from senior bureaucrats in the Health Ministry and the majority of scientific community, apart from a small group of ICMR scientists as well as international experts agencies, I could achieve only moderate success in taking great strides for ICMR. The root of hostility was not my gender, but perhaps my strict adherence to *dharma* (moral/ethical principles), without compromising scientific autonomy/dignity of ICMR. Still, I could achieve a major landmark in constituting first Central Committee to draft comprehensive ethical

guidelines on all aspects of human research in India (1995–97).

What helped sustain my career? I can list discipline, hard work, commitment, strict moral/ethical principles, teamwork, faith in a higher power, as well as music, meditation/prayer, long walks as stress-busters along with a sense of humour.

“Dharmo Rakshati Rakshitaha”
(If you protect your Dharma
(ie., duty with a moral responsibility),
in turn, your Dharma will protect you)



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A dream come true

H S Savithri

I was born into a middle class family in Bangalore. I have an elder brother, two elder sisters and an younger sister. We had our grand parents living with us. My father, the eldest in his family, had the responsibility of educating all his brothers and sisters and getting them married! We always had a lot of people at home and I grew up as one among the many in a small house. My mother was extremely dynamic and could handle all the house work single handed and find time for sitting with us while we studied, stitch our clothes and knit any number of sweaters. She would give us tests before the final exam and correct our papers. She was the motivation for all of us and to set high goals in life. Her greatest ambition in life was to see that all of us got into professional courses and be financially independent.

My parents never differentiated between daughters and son. They encouraged all of us equally to study well. My two elder sisters were already in medical college and I took Physics Chemistry Mathematics in my pre-university instead of Physics Chemistry Biology as I wanted to do something different from what they did. My father encouraged me and sent me to the summer program organized by Bangalore Science forum. There was a nominal fees and it was indeed my father's vision about education that made him pay the fees even though there were other things for which he needed the money.

This was the most inspiring program that I have ever attended. There were lectures by faculty from IISc and we had the occasion to talk to them and ask questions. Most importantly we were taken to the Raman Research Institute where we had the good fortune to listen to Sir C. V. Raman. He was then interested in color blindness in the Indian population and tested all of us personally. I was elated that I could spend 30 seconds with a Nobel Laureate!

I had reasonably good marks in chemistry and I joined Central College to do Chemistry honors, after which I studied Biochemistry. I then joined the department of Biochemistry, Indian Institute of Science and I was fortunate to have N. Appaji Rao, a distinguished enzymologist, as my PhD supervisor. The first experiment he asked me to do was to demonstrate the activity of an enzyme called aspartate transcarbamylase in the crude extract of mung bean seedlings. I had the beginners luck and the assay worked the very first time! One needs to be perseverant, intuitive, and very hard working to succeed in experimental science. I could further demonstrate the kinetic and regulatory mechanisms of the enzyme.

I had the good fortune, meanwhile, to get married to M.R.N. Murthy, an outstanding student in the Department of Organic Chemistry, IISc. The first thing he did for me was to write a program to analyze my data by an iterative procedure that would accurately estimate the kinetic constants, and since then we have had an active collaboration throughout our research career. I wound up submitting my thesis 10 days before my son was born! All along I had the full co operation by my parents, in-laws and Murthy so I could meet all my deadlines!

After the post doctoral work at Purdue University we came back to IISc. Less than a month after we returned we started our work by growing plants in a temporary netted green house to infect them with the viruses we had decided to work. I had a CSIR pool officer position and Prof. Appaji Rao very generously took me back in his laboratory, giving me full freedom to work on any of his projects and to develop my own project. A new student, Suryanarayana decided to work on my project on plant viruses. I

thought he must be brave in making this decision as I neither had permanent position nor any research grant! Our work on the Physalis mottle virus was published in the journal of Biological Chemistry. This was the turning point and I got a position as assistant professor, seven years after returning. Two people who were happier than me were Murthy and Appaji Rao! They have both been most supportive and encouraging through out my research career. In parallel with structural work on viruses, we began to determine the complete genome sequence of viruses. The work in my lab and Murthy's lab has been complementary: his students and mine have worked together, and one of the most pleasurable times for me has been discussions together to analyze and interpret the data and come up with explanations and more experiments and more questions. In addition to research in the lab, both Murthy and I have a strong commitment to spreading scientific knowledge and motivating students to learn science and take it as a career. We have given lectures all over Karnataka and through the center for counseling and support at IISc, I have organized science congress for school children, field trips, summer camps, guidance classes and interactive sessions. The motivation to move on to different areas of research and learn with my students keeps me excited about the work.

At any given time I have had students from various states, backgrounds and capabilities moulding each of them to perform their best has been a challenge. It has been a wonderful time!



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New challenges ahead

Riddhi Shah

I grew up in an old part of Ahmedabad in Gujarat, India. My first school C.K.Bal Mandir was at one end of the street where we lived. In the beginning I loved going to the school, but soon I hated it and walked there as slowly as possible. The houses on our street were row-houses with common walls shared by the houses on either side. There were water taps just outside the houses and I chatted with people brushing their teeth, looked at the cows and buffaloes, still half-asleep on the street and managed to stretch the two minutes' walk to at least ten. As a result of reaching late, I invariably got scolded and often punished by my class-teacher until one day I found her waiting for me eagerly, even beaming. It was my maths result that made her happy. After that day I was punctual again, except on the day of the result, when I went late on purpose!

My father is a civil engineer and mother was a home-maker. For his degree my father had to go to a college fifteen km away. He travelled on a bicycle every day, gave tuitions to pay for his fees and studied under a street-lamp as they had no electricity in the house. He was very good at mathematics and can, even now, do any complex calculation in his head. He was my role-model and I wanted to be an engineer. But my mother used to tell me that I would do a Ph.D. in mathematics. I did not really have any idea of

what that meant. But she would tell me that it meant higher studies and finding new rules and developing new theories in mathematics. This sounded very interesting and easy as I loved mathematics but I still wanted to be an engineer until I was in high school.

My mother always encouraged us (my brother and three sisters and me) to study well. She used to say that we must do at least two graduations. Every day, after we came back from playing, she made us sit down to study. She could not continue her studies after matriculation because of her family's financial problems. That was her only regret. Her house was in front of the town library and she read a lot of Gujarati literature and encouraged all of us to read books from our school library and later the town library. She also insisted on enrolling us in what were considered good high schools, even though they were far from our house and we had to commute by public bus. My grandfather, as well as, my brother and sisters, were all very supportive of me.

I went to the G.M. Prakash High School, which was a girls' school. I liked to fiddle with numbers and once found a simple rule about ordering a particular type of fractions. I used it whenever I could. The Principal of my school, Kusumben J. Shah, was very encouraging and sent me to P.C. Vaidya, then Vice-Chancellor of Gujarat University. He was very kind to me, heard me out and told me it was really correct. But then he asked me if I knew how to prove it! I could check it for any given set of fractions but could not prove it in general. He went to the blackboard, took a chalk and explained a simple proof. It was then that I realised for the first time that one could prove something about an infinite set in a few lines! This motivated me to pursue higher studies in mathematics. I still did not know and would not know until much later, what research really meant.

At St. Xavier's college, Ahmedabad, where I studied mathematics as a major, we had very good teachers. Throughout my undergraduate studies, Shanti Prasanna inspired and encouraged me greatly. She had faith in my abilities, took a lot of interest in my well being and essentially treated me like her daughter. To this day she is my friend and adviser. There was S.S. Vora who used to

be annoyed with my ready answers and no doubt thought that I was acting smart. Then one day he asked us about directional derivatives and I could tell him about its relation to partial derivatives, which he could not find in any book to which I could have had access. He told me about a master's programme in mathematics at the Indian Institute of Technology, Bombay.

Although in those days sending a girl out of town for higher studies was unheard-of in our community, my parents encouraged me to apply to I.I.T., Bombay. I learnt a bit about doing research while doing a project under the guidance of D.V.Pai at I.I.T. After an M.Sc. from I.I.T., Bombay in 1986, I appeared for an interview at the Tata Institute of Fundamental Research for a Ph.D. fellowship. I enjoyed the interview so much that I did not even care if I got selected or not. It took me a while to start on research, especially because all the other students in mathematics in my batch either left or were asked to leave. The pressure to perform was extreme. Here I must give credit to M.S. Raghunathan, who suggested the first problem, and that I work with S.G. Dani, who was working in the area of probabilities on groups. It was Dani's gentle ways of helping that propelled me further. He was always ready to discuss mathematics and answer my questions, however silly, any time of the day. I enjoy collaborating with him and value his advice on many issues, mathematical or otherwise.

Meanwhile, unknown to me, my parents kept all matrimonial proposals at bay. I often suffered from cold-related allergies having moved from the dry climate of Ahmedabad to Mumbai, which is always humid. In T.I.F.R., there were very few women's toilets as there were only a handful of women in the beginning. On some floors, such as ours, there were two men's toilets but none for women! One had to go to other floors even to blow one's nose. Finally, after a persistent campaign of a few years there is a women's toilet on every floor.

It has been a long way from the blissful ignorance of a small-town girl to the fascinating and cosmopolitan world of mathematics. Many people, including my family and friends, have played a role in shaping my career. One special person is my husband, without whose support I could not have made it here; I had free-

dom to pursue my career even though he had a research job elsewhere and we had to stay separated by thousands of kilometres. My parents-in-law showed a lot of understanding, which is rare in Indian society.

Not much would change if I had to do anything differently – I would still like to do mathematics; however, if I had the power I would have ensured that we did not have to go through the years of forced separation and our son would have had both of us around.

Last year we moved to the Jawaharlal Nehru University in Delhi, where we are finally able to live together as a family after many years. The excitement and challenge of shaping a new department of mathematics at J.N.U. marks a new turn in my career.



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Looking for the unknown in the known

Chandrima Shaha

My interest in science was kindled by my father, a remarkable teacher. Although by profession he was not a scientist, he built me a small laboratory complete with a light microscope, Bunsen burner, test tubes and some chemicals. My father believed in holistic education and taught me carpentry, photography, gardening and the reading of classic literature. I spent much enjoyable time with him doing various projects like looking at pond-water droplets under the microscope or putting together a circuit for a small radio. As a result, my interest in scientific enquiry got deeply rooted while I was very young. In contrast, my childhood acquaintances were largely from the fine arts faculty because both my parents were well-known artists of the Bengal school and conversations at home generally revolved around the art scenario the world over, occasionally sprinkled with discussions on a wide variety of culinary delights.

As I grew older, my interests expanded to field studies and I spent considerable amounts of time running after insects and collecting small animals. I spent my holidays in school collecting caterpillars to watch them metamorphose into butterflies and I kept detailed photographic records of the events, using a Leica

camera fitted with a bellow for close-ups. My mother was never interested in my odd desire to keep a variety of snakes and turtles at home, but was tolerant of my inordinate love for animals and appreciated the creative part of my endeavours. I was encouraged in my pursuits by my biology teacher at school, who took a special interest in my collections of butterflies, caterpillars and beetles. Childhood events being most essential for scientific and philosophical development, I feel that the early influences that shaped my future interests were my family and committed school teachers.

After finishing school, I continued to be obsessed with nature and thought that being an entomologist would be most wonderful, as I could be in the field as well as in the laboratory. While in college, I developed other interests. I became vice-captain of the Bengal women's cricket team at a time when women's cricket was at a nascent stage and women were just storming this male bastion. Cricket brought a completely different flavour into my life because team activity was very enjoyable. Our success in winning the National Championship for three consecutive years was certainly delectable! My parents were supportive of my interest in sports and gave me the free choice to do whatever I most preferred.

The interest in science instilled in me during my childhood propelled me more towards academics than sports. Nevertheless, I maintained my interest in sports by doing commentaries on men's cricket during the winter on All India Radio, although I could not participate in zonal tournaments due to academic commitments. At this time, I was introduced to my first experiences in a real laboratory set-up, and during post-graduation I chose endocrinology as a subject for specialization because the course interested me. I completed my university sojourn, looking forward to getting involved in full-time research, and thus my formal involvement in a life in science was initiated. In retrospect, I feel that the constant support my parents gave and the atmosphere of creativity at home influenced me to choose a career that ensured intellectual pleasure. In later years, whenever my work has received national recognition, I have regretted that my parents were not there to share the events.

After formal training in endocrinology, I was particularly

interested in the events of reproduction because that provided an opportunity to understand the fascinating phenomenon of how life begins. The major obstacle at this period was to find a suitable laboratory to pursue my interests. Fortunately, I got a placement at a reputed research institute now named the Indian Institute of Chemical Biology (IICB), in a laboratory that offered the possibility of doing reproductive biology research. After completion of my doctoral studies, my interests took me to Kansas University Medical Center in the United States with a Ford Foundation Fellowship, where I was able to pursue my interests in female reproductive physiology. Even though the empty streets of a midwest American town were disconcerting after the vibrant city of Kolkata, the very active laboratory soon made me feel comfortable. I worked on the mechanisms related to ovarian steroidogenesis in the years I spent in this laboratory, towards the end of which I was interested in studying similar phenomena in the counterpart of the ovary in males, the testis. Exploring the research interests of various laboratories, I decided to join The Population Council at New York City which was located on the campus of the Rockefeller University that in turn was surrounded by two great institutions, the Sloan Kettering Memorial Hospital and the Cornell Medical College.

I spent two very productive years of my life at this laboratory, working on the involvement of opiates in testicular steroidogenesis and functioning, following which I joined the National Institute of Immunology in New Delhi, then an upcoming institution. It was difficult to decide whether or not to join a new institution because working modalities in most new institutions face teething problems, and I did face such problems. However, I now look back with great fondness at that period of instability, surprises and continuous pressure. I have realized that there are very many experiences in life which appear different when you look back at them over the distance of time rather than when you are actually undergoing them.

At the National Institute of Immunology, I started a laboratory with a group of people interested in exploring the possibilities of developing a vaccine against male fertility, and after about a

decade or so, we extended our interests into probing the modalities of male gamete survival, information on which had the possibilities to contribute to the success of a possible vaccine. While my laboratory still continues to address questions pertaining to male gamete survival, my evolving interests have impelled me to start investigations on issues regarding the survival of a host and a parasite when they interact. I feel that my ability to carry out research on problems that are related in essence but different in their identities, has contributed greatly to my evolution as a scientist, kept my interests alive and created a lot of excitement in laboratory life.

The writings of Rabindranath Tagore, whose songs and poetry I grew up with, have been the primary inspiration in my life. He said, 'Look for the unknown within the realm of the known and you will realize many mysteries of life', which essentially defines work in science. When I look back on the journey from my doctoral days, I feel fortunate to be associated with scientists of repute, who were my mentors and provided considerable encouragement for my work. I also realize that my colleagues from far and near have made life interesting along the way. I feel particularly fortunate to be in a profession which has provided so much excitement and intellectual satisfaction, and if I had to start all over again, I would still like to be a scientist. To conclude, I feel that I should express my feeling on survival as a woman scientist in a largely male-dominated community. Since both my parents were non-traditional in their approach towards my growing up, it never came to my mind that I could not do something because I was a woman. It is possible that I was more privileged than many women in a similar situation. May be there were times when obstacles cropped up, but I never felt them much because I was moving forward. As a teacher, as a scientist, it is my desire to see more talented young women decide to take on science as a career in these changing times. I am sure they will not be disappointed.



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From the abstract to the concrete

Priti Shankar

The earliest memory that I have of studying something I really enjoyed, is learning elementary school algebra from my mother. She was a school teacher, and taught mathematics and French in high school. The year was 1958, and we were about to move from Khadakvasla in Pune, to Jammu, as my father, an officer in the Indian army, was posted to Surankote, a small town on the border between India and Pakistan. I had to be coached for the next class, having missed six months of school. I remember the pleasure of being able to convert a problem into an abstract formulation, using variables for unknowns, and then actually getting the answer by solving simple equations. It appeared magical at that time.

A few years later, we moved back to Pune again, and I joined Fergusson College. I later went on to IIT Delhi, where I completed my BTech in electrical engineering in 1968. I was in fact, the first woman electrical engineering graduate of IIT Delhi!

In 1968 I left for the U.S.A., to begin graduate studies in the department of electrical engineering at the University of Maryland in College Park. Among the courses I took, I was particularly fascinated by one on error correcting codes. It was a beautiful ap-

plication of abstract algebra to the very practical problem of reliable communication. I decided to work in this area for my PhD, which I finished in 1972.

I returned to India in 1973, and was appointed assistant professor in the School of Automation, a relatively new department at the Indian Institute of Science. There were very few faculty members in the department then, and we carried fairly heavy teaching loads. I greatly enjoyed interaction with the students, and it was wonderful to see a fresh set of faces every year.

In 1974 I married P.N. Shankar, a theoretical fluid dynamicist. We had met while I was a graduate student, and he had returned to India in 1972, to join the National Aeronautical Laboratory, Bangalore. I took a break from work after the birth of our son Nachiket in 1976, and then again after our daughter Mridula was born in 1983.

I spent the first few years designing and teaching new courses, among them courses in formal languages and compilers. While at Maryland I had taken a course on the theory of computation, where I first learned of the work of Noam Chomsky and Alan Turing, and the existence of undecidable problems. The application of automata theory to compilers was an elegant illustration of the process by which an abstract specification could generate a concrete implementation of a complicated piece of software. I continued to work in coding theory as well as in the design and development of practical compiler tools. In 2002 a colleague and I edited the first handbook on compilers.

Raising our children took up much of my time outside working hours, and managing the house as well as my duties at work was a tightrope walk which I managed with support from my husband and my parents.

I often wonder whether I would have lived my professional life any differently were I to start all over again. I think not. I've pretty much done what I wanted to, most of my life. I consider myself very lucky to have been born into an enlightened family where independent thinking was encouraged, and to be associated with an institution where complete academic freedom is given to faculty members.



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My interest in promoting more women in science

Manju Sharma

In my early years, I was tremendously fascinated by music, dance and culture, and my family thought that I would become an artist. In class five, I had a great biology teacher and I started taking interest in botany. After that, I was fascinated by plants; with a fairly good memory, it was possible to identify and classify them and remember all their names. In college, my friends started calling me the 'encyclopedia of plants'. As soon as I joined B.Sc., it was clear to me that I wanted to become a scientist. My inspiration was Marie Curie, about whom I read a great deal.

Basically, there was no specific influence *per se* which made me choose a career in science. It was my own decision. I must also admit that in pursuing a career in science as a student, I did not come across any major obstacle from my family or teachers and I finished my thesis in the shortest possible time. My Ph.D. guide, Prof. A. R. Rao in the department of botany at Lucknow University, was a great source of inspiration. I then had a very productive post-doctoral period at Purdue University with Prof. A.C. Leopold, and later at the University of Copenhagen. The problem started when I came back to India and wanted to join a particular

institute to pursue my research. I already had a pool officership, but I was not able to join the institute and eventually I had to leave my active research career and join the government in a managerial position.

This was the turning point in my career. My love for science, self-confidence and above all my will power helped. No matter what obstacles arise, if you are determined to fulfil your dream, all you need is dedication and hard work. I took up science management and administration as a challenge and wanted to use my scientific knowledge, my deep commitment and love for science, as well as my confidence in science and technology as a major vehicle for societal transformation. Things did work the way I wanted!

It is important to mention the names of some very distinguished scientists of this country who were not just a source of inspiration, but were very supportive and provided mentorship, guidance and encouragement to me. Starting with Prof. M. S. Swaminathan, Dr. A. Ramachandran, Prof. M. G. K. Menon, Prof. A. K. Sharma and Prof. P. N. Tandon; all these eminent personalities, at various stages in my life, have played a pivotal role in helping me to arrive at suitable decisions and also guided me in promoting and processing science at an accelerated pace.

There were many critical moments when, because I am a woman, I faced serious problems and hurdles in pursuing what I wanted to do, but with the tremendous support and encouragement of a large scientific community, especially younger people, I never lost my confidence and faith in pursuing the promotion of science.

It has been a wonderful experience working very closely with the scientific community both in India and abroad, both with senior people and the younger generation. This satisfaction along with many achievements have helped me to sustain my career in science. The human angle always received priority in my working approach. I also strongly believed in the consultation process involving the scientific community at all levels. I was conscious of the need for national, regional and international development of biotechnology as also strong networking and linkages

to benefit from 'each others' experience and expertise. In particular, I am happy with the success I achieved in promoting the field of biotechnology and biology in a manner that will be truly relevant for the country.

An area of concern to me is the need for a skilled human resource pool and reducing regional imbalances in the field of biotechnology. I feel strongly about the need for full utilization of fifty percent of the human resources in the country—women in the development of science and technology. I am convinced that women can contribute to the progress of science and technology, bring in more diversity, enrich the cause of science and help in capacity building. The other burning issue always on my agenda was the working and living conditions of the women in rural areas: their drudgery, the prevalent gender disparity and bias, and low incomes. I was desperate to do something for them and I continue even today, as far as possible, to take more and more initiatives in this direction.

I was asked by Dr M S Swaminathan to write a section on science and technology for women in the sixth five year plan (1980-85). This gave rise to the first focused scheme on the subject, which has been operated since then by the Department of Science and Technology. Since then I have continued to work on this theme the latest being the report which has now been accepted by a large number of academies of the world.

I am confident that the twenty-first century will see many new dimensions of the progress of women scientists and technologists, and witness large-scale scientific and technological empowerment of women, especially at the grassroot level. Our country will achieve its goal of being a 'knowledge society' and generating wealth from knowledge, once this fifty percent of its human resources is equally and scientifically empowered and made technologically self-reliant. Presence of woman in leadership and decision making positions will help to achieve this goal faster.

Gandhiji had a deep appreciation of the value of educating women, who are the first teachers of their children. He said "When a man is educated, an individual is educated, when a woman is educated, a family and a country are educated".

It is of utmost importance to attract more girls towards a career in science and to work for underprivileged women, especially taking care of their health, nutrition and livelihood requirements. I appeal to all the women scientists in this country to launch more initiatives for the welfare of women and young girls. A cadre of women scientists and technologists would accelerate the pace of socio-economic progress in this country. Despite hurdles and difficulties one has to undergo to achieve some success in life, one should never give up.

I feel that women are the most wonderful creation of God. As beautifully described in the words of Rabindranath Tagore:

“Women, when you move about in your household service your limbs sing like a hill stream among its pebbles.

Woman, thou hast encircled the world’s heart with the depth of thy tears as the sea has the earth.

Woman, in your laughter you have the music of the fountain of life” (Poem “Stray birds”)



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A matter of chance, environment and inclination

Shobhona Sharma

Why did I opt for science subjects in school, and choose a career in science? Perhaps the best answer would be 'Chance, Environment and Inclination'.

Here I am, considered to be a professional woman scientist, working towards understanding the biology of the malaria parasite and the challenges put up by the same. I have enjoyed a reasonably fulfilling scientific career without having to compromise on my family front - husband and two children. However, at three points in my life it almost did not happen.

The first and the most difficult hurdle was when my father objected to my going to Bombay (TIFR) for Ph.D. "A corrupt city" he insisted - "Really bad for young girls. Stay with us at Calcutta, and I will make sure that you can join whoever you wish to in this city for your Ph.D." Time to get out of the direct influence of such 'protective and proactive father' - I thought.

Next - when I appeared for my Ph.D. interview at TIFR, Bombay, one of the chemistry professors offered me a lecturer's

job at Sophia College - a 'permanent job with twice as much salary' as my fellowship at TIFR would be! I was tempted, but was pulled back by Katie Daruwala, my elder sister's friend, my guide and philosopher at that point of time. "You will get plenty of opportunities to teach in a college after your Ph.D. If you qualify for Ph.D. in TIFR and not take it up, you will regret for your entire life" she said. I did join TIFR for Ph.D., but I do not quite know what I missed! A comfortable permanent job would certainly have led to a less stressful life. However, I guess that may not have been as exciting.

A major dilemma is faced by a 'professional' woman when she wants to start a family, and I was no exception. I was 32 years old, and we realized that we needed to start a family - then or never. At that stage, my husband Dinesh had just joined Research Triangle Park in USA, while I was at New York University Medical Centre, doing very well with two science papers published on the then 'hot' and 'sizzling' recombinant DNA technology applied on the malaria parasite. I did not find suitable groups to move to and almost gave up my career in malaria. However, Nigel Godson (my boss at that time) and his friend Mike Parkhouse, organized that I should work in the immunology group headed by Ron Corley at the Duke University Medical Center. They figured that some training in immunology would help me in my future ambitions on studying malaria. At that point my knowledge of immunology was nearly zero, and I marvel at the fact that Ron Corley accommodated me in his very classical immunology group.

Having my career in jeopardy thrice in my life (not to mention small perturbations - when transiently one feels like giving up everything and quitting), I have learnt one main lesson. Next day will be better and is likely to bring in fresh opportunities. I would like to tell all - please do not interrupt your career for any reason. It is better to be clear that on certain days you just *have* to be at work, and therefore in case of an emergency, your spouse should take leave. Do this from day one. If you take a break and look after your home affairs for a few years or even some months at a stretch, then it gets difficult to change the norm, and catch up professionally. Children, get used to you being at home, and be-

lieve me - children; spouse and parents can blackmail you emotionally very effectively. As a scientist – stay with scientific practicality, and do not give in to such emotions.

How did I imbibe/learn such tactics? I have been lucky to have had huge support from various quarters. I was born in Calcutta in a typical Bengali family, but was brought up in Delhi. I studied Science in Lady Irwin School and then pursued chemistry honours in Delhi University. I was taught by some excellent teachers. Dr. V.M. Khanna, our Physical Chemistry teacher in B.Sc., gave us tough assignments with unusual problems, and subjected us to open-book tests quite early. I am most indebted to him for my foundations in science. Amongst my family, my father may have objected to my going to Mumbai, but he was all for higher education and a career. My husband has been a tower of strength and support. He actively discouraged me from traditional 'homely' activities such as cooking and encouraged and tolerated my taste and talent with other hobbies such as photography or gardening. My elder sister indoctrinated me into modern biology and egged me to pursue science. Without her I may have been working in some chemical factory, perhaps earning much more money, but deprived of the thrills of biology research and discovery.

Reflecting back on my career, I know that circumstances have played a major role in my life. Balancing a home and a job is not easy for a woman - even now. However rational or scientific a couple may be, the worries of running the household falls on (and are accepted by) the women. Since women multi-task well, they go on with their jobs and worries at the same time, while men concentrate on their jobs. To have women put in their best in their jobs, it is necessary to take care of the family and those worries. Until that happens, the representation of women in demanding professions will continue to be low. It is important to note that the norms for excellence are defined by experts (historically men), who may not be sensitized to inherent gender differences. By having more women in policy making bodies, and more men involved in caring for home and children, hopefully the norms for an excellent professional life will even out for the two genders.



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Meandering into astrophysics

Prajval Shastri

I was born a year after Sputnik. I grew up in the mofussil town of Mangalore. One of my sweetest childhood memories is that of lying on a mat in our garden watching the night sky: the Milky Way (visible those days (nights!)), meteors streaking across, and human-made satellites slowly winding their way “between” the stars. Also a comet, which I watched for hours, and painted, with our mango tree in the foreground. The cosmos fascinated me and I recall my disappointment at about age seven that humans had not yet landed on the moon. Nevertheless, Yuri Gagarin became my childhood hero and Valentina Tereshkova was a household name. I often dreamt of becoming a scientist working on a spaceship.

My rationalist parents bought me several enchanting childrens’ science books. One called Atoms, had a lovely illustration of Rutherford’s experiment wherein a gold leaf was bombarded with alpha-particles, of which a few “bounced back”. So most of the atom was in a small volume and the atom was mostly empty space! The beauty of that experiment made a deep impression on me.

When I was eleven, my father had me read *Andromeda*, a science-fiction novel by Ivan Yefremov. It is a fascinating tale of space exploration, inter-planetary contact and different life forms, but also of a new “sociology”: of deep and open relationships between people regardless of gender, and with the unmistakable underlying belief in the liberating capacity of science and technology on the one hand and in the inevitability of equity for all peoples on the other. *Andromeda* built for me my utopia.

As I entered my teens, my mother had me read Eve Curie’s biography of Maria Skłodowska Curie, – of her solid intellectual as well as tenderly emotional partnership with Pierre Curie. I cannot say whether the book influenced my career choice. But the vision of Marie sticking out as a female in her science class was stark, perhaps my first eye-opener to the gender inequities of the scientific world.

School had many teachers who in their own instinctive and committed way transmitted the joys of learning, whether in the enchantment of a history narrative, the nuanced puzzles of Kannada grammar, or the fun in mathematical logic. College brought the need for choice: Science and Mathematics versus History and Political Science. I wanted to study both. The clinching argument to choose the former was simply that I could switch later, but not the other way around!

Each of my college teachers was passionate about what they taught, and instinctively emphasised process over outcome, whether it was puzzling out a maths problem, classifying a plant, measuring the Sodium doublet or dissecting a cockroach. A love for empirical work, in fact not seeing it as inferior to or even disparate from theoretical work, is an ethos I certainly imbibed in my mofussil-town college; an ethos I distinctly missed in my more prestigious later institutions.

By then it was clearly Physics for me – the foundational science, spoken in the language of mathematics which I loved, and testable in the ‘oh-so-fun place’ the laboratory. Of course my naive childhood dream of becoming a scientist on a spaceship had long faded. For one, we were barely launching vehicles into space! For another, becoming a cosmonaut appeared to involve passing

through the air force, a military link that I found unpalatable.

Entering the Masters' physics programme at the Indian Institute of Technology, Bombay was exciting. Lodged in the only womens' hostel, it was a thrill to find so many there who shared my passion for physics or sciences in general. Flowing with the IIT "physics mob", Ph.D. seemed the automatic next step. I entered the Tata Institute of Fundamental Research wanting to do experimental nuclear physics, mostly inspired by my favourite IIT teacher P.P. Kane. While teaching that subdiscipline, he opened up for me the world of research. The idea that realisations of equations in the laboratory were not merely fun, but could actually be used to discover something hitherto unknown, fascinated me. Encounters in TIFR, however, had me seeing astrophysics as standing tallest as my choice. Little had I imagined that a hobby would actually turn into a vocation! On the one hand it used cutting-edge technology to probe the universe – adding so many dimensions to the skyscape seen by lying on a mat in the garden. On the other hand, that skyscape was enormously complex, but yet enchantingly amenable to the laws of physics. I was simply floored by it all.

Having the late Vijay Kapahi as a mentor was among the best things that happened to me. He sparked my interest in the workings of active galaxies, the most powerful objects in the universe, driven by the gravity of extremely massive black holes. Vijay treated the puzzles at the centres of galaxies (indeed anything he took up) with both passion and playfulness, an approach which was truly inspiring. He was also completely gender-blind in relating to students and colleagues, a rarity then and now.

Meeting my spouse, an engineer turned environmental scientist, brought a shared growth and exploration that led me to a far more critical understanding of practiced science than my childhood dreams had built. An old college friend recently recalled my excitement in 1974 at India's first nuclear "implosion" – reminding me as to how naive a believer I was then in "peaceful uses of the atom", indeed in the religion that science and scientists would lead humanity up the path to abundance and equity. But ultimately, science is a human endeavour, shaped by social processes,

and embedded in its practice are all the human failings. The outrageously low numbers of women scientists, in a pursuit that prides itself on being “objective”, is a classic illustration of this fact. For me, how natural and unremarkable it is that other women are passionate about physics! But how equally naturally do colleagues see a woman wanting to do physics as doing it primarily for “time-pass” until succeed in finding a spouse!! I await the day when my (or anybody’s) gender would be only as important as, say, my taste in fiction. No wonder I get wistful about the utopia of Andromeda, for the healthy and openly warm relationships between people regardless of gender.

Nevertheless, the dances of matter around massive black holes at the centres of galaxies, with embedded magnetic fields forming fiery hoses that squirt at near-light speeds, continue to fascinate me. These processes manifest at every wavelength of the spectrum, which means physical principles from several sub-disciplines play out, making astrophysics “the last bastion of the generalist”, as Ter Haar put it. It also means working with telescopes on the ground and in space, bringing international involvements and making one part of a global but close-knit community. The challenge of not having controlled experiments to test hypotheses adds to the excitement. The icing on the cake is the use of cutting-edge instrumentation as well as complex mathematical techniques to tease out secrets from the depths of the universe. The beautiful images catch the public imagination, making astrophysics a great tool to perpetuate a scientific temper. Astrophysics is also a delightful vehicle in which to traverse life – a continual reminder that we are scientists because we are lovers of nature who seek to understand her beauty. Ultimately, the enchantment of watching the night sky on a mat in the garden is only enhanced by understanding its overlying workings.



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At the interface

Somdatta Sinha

As a child I travelled widely because of my father's transferable job. This had an interesting effect, as I did not have to grow up in the midst of strict social norms of any one particular place. After my father's untimely death, we, a family of three women, settled down at Santiniketan, which is known for its artistic and literary environment. I had the privilege of spending most of my formative years in this place, where the community encouraged academic pursuits over monetary gains, and nature-based cultural celebrations were part of the social fabric in which children grew up. I also was lucky to go to a school there, which was based on Tagore's ideals of the free mind.

My mother told us, her two daughters, that whatever we studied we had to do well and earn scholarships to continue. I liked the logical approach in science and did well in science. So with my teachers' encouragement I chose science in high school. Reading about scientists like the Curies, who dedicated their lives to solving scientific problems despite many obstacles, inspired me greatly.

I had no second thoughts about pursuing an undergraduate, and then a postgraduate course in physics after obtaining the top rank in school. We faced social and economic challenges, and

lived very simply. The National Science Talent Scholarship (NSTS) went a long way to help me with my studies. My mother must have shielded us from many assaults, like well-meaning relative's suggestion that "guardian less" daughters be married off early. This was possible only because of continued support from my teachers and the community. I remember that I never had new books in school; they came from seniors, who were happy to help. The book grant that was part of the scholarship was of great help. A loner in college, I spent all my time trying to excel in examinations, and read a lot of science magazines and books borrowed from teachers and the library.

While a student, I wrote a few articles for Bengali science magazines, as I felt that science could reach a wider audience if available in their native language. I could attend only two summer camps of the NSTS, and made lifelong friends there, some of who are now renowned physicists. Since I came from a small town, the camps gave me a chance to see how I compared with other physics students from all over India. They also exposed me to some excellent institutes of learning, great teachers and a research environment. The only thing I was denied by my mother was going to college in Kolkata. That certainly was a defining decision, which changed my life completely. It was a time of social turmoil in Bengal. There was unrest all over the world, with student uprisings in universities in France and the U.S. and political wars in China, Cuba, and Vietnam.

The 1970's and 80's were very interesting times in science. Walls between different scientific disciplines were increasingly being knocked down. Studying physics, I came across more and more physicists looking at the world and wondering how nature weaves such beautiful patterns. I loved the intricacies of the cosmic dance of the elementary particles and their fields, which were understood only in terms of mathematical equations and logic. But at the same time I looked around and was amazed at the shapes and arrangements of the leaves and flowers, the symmetry in the body plan of organisms, and above all the endless robust elaboration of all these over and over in time.

I crossed over from studying elementary particles to

macroscopic biological objects – albeit theoretically – after completing my M.Sc. I took this decision on my own, based on my understanding of the nature of science of that time and the time to come. I chose to join a newly started course in Theoretical and Environmental Sciences at Jawaharlal Nehru University in New Delhi over Physics at an I.I.T, for graduate studies. This was my first step towards the interface between physics and biology. Nobody really had a clear idea at that time as to what theoretical biology meant, and I wandered around trying to understand what I wanted to do. I wrote to those whose papers I had read, and then travelled to the Centre for Theoretical Studies at the Indian Institute of Science, Bangalore. Shuttling between J.N.U. and I.I.Sc. several times in the space of two years, reading many papers, having lots of discussions with teachers and friends, both from biological and theoretical sciences, slowly guided me to develop some ideas. I finally stayed at J.N.U. and carried on a programme to study developmental processes in Hydra, using both mathematical and experimental tools. The highly academic environment of I.I.Sc. and the high quality socio-political environment of J.N.U. influenced my life and way of working. I learnt a lot from both places.

Though I had worked on models of circadian rhythms (at I.I.Sc.) and pattern formation during development in Hydra (at J.N.U.) for my thesis, I developed a general interest in biological processes. On seeing the advertisement in Employment News, out of sheer curiosity I applied for a position in a newly formed institute in Hyderabad, the Centre for Cellular and Molecular Biology and I joined in 1983. One of the first institutes to start a programme on theoretical biology, CCMB had a highly developed work culture, strong emphasis on originality and imaginative thinking, and a very active group of young faculty along with strong leadership. I was encouraged to work at the interface of theory and biology. Though I learnt a lot of biology from my colleagues here, it has mostly been a lonely journey. The area was new and it has been a continuous struggle to be accepted by the community, as I was neither a trained biologist nor a card-carrying physicist. But I continued alone, with determination to do what seemed to me a

worthwhile endeavour, although few recognized its importance then.

It is only during the past ten years, with the surge of activities in genomics/bioinformatics in one hand, and evolution of a new sub-discipline called soft condensed matter in physics on the other, that many more theorists are getting interested in biological problems, and biologists are becoming more and more aware of computational studies. For example, some of my work published in 1988 on biochemical pathway modelling has suddenly been noticed during the past two years by people in the field. What helped me sustain my objective to work in this interdisciplinary area is the sheer wonder of the intricate designs in biological systems at all levels of organization. Will we ever learn how all this comes about?

I am glad that I lived in times that were interesting both scientifically and socio-politically. I am so grateful to my family, friends and teachers for having encouraged me to choose and continue in basic science, especially physics, as my field of enquiry. The tremendous surge of interest in understanding nature by using all possible approaches – experimental and theoretical – makes the pursuit of science very exciting now. Sometimes I wish that I could start my life in science now, so that I could study physics again and try to understand the codes of life using physical principles.



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Empathy, not sympathy

Sudeshna Sinha

Unlike a vast majority of women, I never really faced any strong gender bias. Consequently my story is not one of heroic struggle. But still its a story that needs to be heard, as it underscores how the positive presence of certain people, such as parents and spouses, in one's personal life can aid professional fulfilment.

I had the great good fortune of having enlightened parents. I had a childhood where being a girl child was not an issue at all. My parents insisted on very little, and believed that I should (and could) figure out what was best for myself. With freedom came responsibility, and at a fairly young age I learned that I was fully accountable for my choices.

I remember going with my father for counselling to IIT Kharagpur when I was about seventeen. The counsellors told my father that perhaps I should opt for Kharagpur, as it was closest to my hometown and they could drop by and "check on me" as often as they thought fit. My father firmly told them that I had set my heart on IIT Kanpur and so he would encourage me to stick to my choice, unless there was an academic reason to rethink my decision. I remember the feeling of pride at having my decision respected, even when weighed against the advice of the counsellors, and also an overwhelming sense of gratitude for having the parents I did.

When I went to IIT I was initially completely overwhelmed by the gender imbalance. I remember I had mistakenly first been allotted a room in a boys' hotel, because I had forgotten to specify 'Kumari' in front of my name! I still recall standing in the quadrangle with my luggage, besieged by catcalls, praying that some miracle would render me invisible! I was the only girl among the forty students in my section. It was a lonely and tense time, but those difficult initial years lent me a certain toughness, which came in handy later. I learnt to depend on my own resources completely, and though I made many mistakes, I also learnt to bail myself out of potentially damaging situations. And most importantly, I had learnt to acquire "internal blinkers" to help me get on with my life just the way I wanted to live it, regardless of pressures from outside to conform to certain patterns.

In TIFR I met Kapil, my husband of two decades, and in meeting him I was plain lucky. He understood me well enough (perhaps better than I understood myself!) to know that I would be deeply unhappy if my professional life was unfulfilled. I am grateful to him – for never letting me give up. To him it was important that we both had equal opportunities for professional growth, even if "equal" implied less than the best that was on offer for him.

Often a turning point of women's personal and professional life is motherhood. Since timing is the single-most important factor in balancing motherhood with a career, we tried to time the expansion of our family as best as we could. I suppose, ideally, one should have a faculty position before starting a family. I didn't quite manage that (though I was close). I remember going for a job talk when I was carrying my daughter. I wore an umbrella-cut kameez to disguise my growing girth! I was afraid that my impending motherhood would render me quite unemployable. I did get that position however, and I like to believe that my employers had realized that I was pregnant (in spite of my tent-like attire, or perhaps because of it!), but still thought I was worth hiring.

I enjoy motherhood in a way I had not even imagined possible. I treasure our daughter, and I am grateful for her in my

life. But motherhood, especially in the first four years, did make demands on my time in a manner nothing else had done till then. I took a complete break for eight months and even when I went back to work, so much of my mental and physical energy was centered around my daughter that there was some inevitable slackening of my academic drive. For the first time in my life, my time was not entirely my own. There were occasions of conflict between career demands and needs of my daughter. At this stage, the key to sustaining some reasonable level of academic activity, was efficiency, discipline and time-management. I remember I valued time in a way I never had before! Arguably I was not as productive as I should (could?) have been in this period. But I reckoned, viewed in the perspective of a working life spanning four decades, this dip of professional energy for a few years was not that significant.

There is one last observation I have: while I cruised along professionally in my early thirties, I did feel a transition in the attitude of my peers when I was approaching forty. There was a subtle (and not so subtle) shift from treating me as an younger colleague they enjoyed hanging out with, to a serious competitor in the work place. I often heard my productivity dismissed as “she just writes many papers”, and my several single author papers seen as evidence of some kind of “inability to collaborate”! In all honesty I am not entirely sure it has to do with being a woman, but perhaps this is how a “glass ceiling” manifests itself in academia. In a sense, the idea of a woman as competent, organized and hard-working is easily acceptable, but brilliance and ingenuity is not natural to her image. So it is most crucial to hold that centre of self-belief steady. And it is important not to care too much about what other people think.

I am acutely aware how much could have gone irrevocably wrong at every stage of my professional life. And so I feel incredibly lucky to have the wonderful parents I did, and later on a truly supportive husband. They provided me with that little bit extra strength one needs to stay afloat in severely gender-imbalanced work environments.

Lastly, for all those men reading this, perhaps fathers, brothers, husbands or teachers of women scientists, I would just like

you to remember that what women want in their professional life is exactly what men want. Women need empathy not sympathy, and a true acceptance of the fact that there are probably fewer differences between women in science and men in science, than between men in science and men not in science.



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Like mother, like daughter

Purnima Sinha and Supurna Sinha

The most significant influence that led me to pursue science has certainly been my mother, Purnima Sinha (née Sengupta), a physicist, the first woman PhD from Kolkata University in Physics. She had the great privilege of working with Prof. S. N. Bose, the discoverer of Bose statistics and a product of the Bengal renaissance. Infact, he had insisted that she fabricate her X-ray equipment from scratch. She did this from surplus army equipment which was sold as scrap on the footpaths of Kolkata after the Second World War. [See *Box* where she has reminisced about her experiences of working with S.N. Bose].

After her PhD., she worked in Biophysics at Stanford University, U.S. on the ‘Origin of Life’ during the year 1963–1964. This work was at the interface of biology and physics, studying structures involving clay and bases appearing in the DNA double helix. She worked at the Geological Survey of India and the J.C.Bose Institute for twenty years. After that she worked at the Central Glass and Ceramic Research Institute on physics of ceramic colour. She is now retired and continues to popularize science by translating books like Schrodinger’s ‘Mind and Matter’ and Kamenetskii’s ‘Unravelling DNA: The Most Important Molecule Of Life’ in Bengali.

Let me flash back in time and take a look at the family atmosphere she had grown up in. Her father Dr. Naresh Chandra Sengupta was a constitutional lawyer and a progressive writer who had written over sixty five books and several essays in Bengali as well as in English, some of them on Women's Education. Many of his novels centered around themes related to emancipation of women. He had an overwhelming influence on the family.

Around the middle of 1951 I started working on my Ph.D. with Prof. S. N. Bose at the Khaira Laboratory in Kolkata. He advised me to carry out an investigation on the structure of clay from various parts of India. He suggested that I could use techniques of thermal and chemical analysis along with X-ray scattering and also suggested that I fabricate my own X-ray tube of the Coolidge kind so that the parts could be dismantled and put together at will.

At that time about ten of us were involved in experimental research at the Khaira laboratory. Each of us used to fabricate his or her own instrument according to individual need. This was an unwritten rule in our laboratory. The more experienced research students used to initiate newer students in this mode of doing research and Prof. Bose would routinely keep track of the problems we faced in the lab as well as our progress. There was constructive cooperation between fellow students and people working in related departments. We all enjoyed the excitement of doing science in this manner. Because of the desire to hasten the pace of doing research there has been a trend towards buying easily available expensive imported equipment. It would have perhaps been possible to develop a much more self sufficient and confident scientific culture in the applied sciences in our country – in spite of the slower pace – if the ideal set by Bose had been followed.

The high voltage transformer used for our X-ray equipment was fabricated in the applied physics department of our university. We had put together our X-ray equipment from the

World War II surplus gathered in the lane behind Dr. Bidhan Roy's house. The rest of the parts were put together at the workshop in our department.

Our efforts in the X-ray laboratory finally led to a complete classification of about fifty clay samples into categories like Kaolinite, Montmorillonite, Illite, Vermiculite, Chlorite and so on. The results of this investigation were put together in 1955. In 1956, Prof. Bose retired from Kolkata University and we did further detailed X-ray studies of the structural characteristics of these clay samples in collaboration with Prof. Kamalaksha Dasgupta.

Since that time years, many publications on X-ray analysis of clay samples have come out of the Geological Survey of India, Central Glass and Ceramic Research Institute, Indian Institute of Technology and many other institutes. Few will realise that it was S. N. Bose, one of India's finest theoretical physicists, who first initiated research in X-ray based structural analysis of clay samples from different parts of this country!

The photograph on page 1 shows Purnima Sinha (n`ee Sengupta) with S. N. Bose and P. A. M. Dirac during Dirac's visit to Bose's laboratory in the mid 1950's when Purnima was doing her PhD. research with Bose.

Purnima Sinha

His four daughters, my mother who is now 80, and my three aunts pursued Physics, Economics, Mathematics and Chemistry. This significant thrust on focussing on higher education for women had percolated to the next generation as well. Among my maternal cousins there are several women scientists pursuing Mathematics, Molecular Biology, Statistics, Medical Sciences and so on. Consequently, I grew up with a perspective which I now realize, is significantly different from what most people grow up with. My world view has been shaped by these exceptionally emancipated

women and I have grown up to believe that such women are the norm rather than the exception.

Coming back to the present and the nuclear family that I have grown up in, I have been very fortunate. My anthropologist-artist father and my mother who has been as much of an artist as a physicist, had fostered an atmosphere for my sister Sukanya (now a physicist at ISI, Bangalore) and me, where learning, understanding and creating were an integral part of our lives. Visitors at home included poets, theatre personalities, filmmakers like Satyajit Ray, visual artists, musicians and scientists like Nirmal Bose, my father's mentor and Satyen Bose, my mother's mentor. In my younger years I had as much interest in the Fine Arts as in Mathematics. At home we had access to a large collection of excellent Physics books which my mother used to study. However, my real appreciation for Physics as a subject with a unique blend of logic and connection with the natural world happened a bit later. During my preuniversity years Anjan Dasgupta, our Physics teacher in South Point High School, Kolkata, showed many of us what this beautiful subject is all about.

I left India and joined the Physics department at Syracuse University for a MS-PhD. in Physics after completing my BSc. in Physics in India. Around the end of my course work at Syracuse I increasingly found theoretical condensed matter physics as a more attractive subject to pursue because of its greater connectivity to experiments compared to High Energy Physics or Gravity. My teacher Ranjan Bhattacharya and my uncle Shyamal Sengupta have had a definite influence in my making this choice. A theoretical condensed matter physicist named Maria Cristina Marchetti joined the Syracuse Physics Department and she was a natural choice for a research guide for my PhD.

Till the end of my PhD. years, my experience in doing Physics has been very positive. All my teachers, as well as my fellow students across gender have been encouraging and have often appreciated my style of doing Physics and my point of view in solving problems.

In my later years I have grown to admire Cristina's courage, doggedness and motivation in her pursuit of science,

balancing her dual identities as a scientist and a mother. I did not appreciate these issues until much later when I faced gender based discrimination myself. One great source of inspiration during my PhD. years was Rafael Sorkin, with whom I worked on a paper on quantum diffusion. His penetrating mind and open minded thinking in Physics and beyond has greatly influenced me. During my PhD. years at Syracuse I met Joseph Samuel, a theoretical physicist whom I married later. After my PhD., I had got postdoctoral offers from Europe, the United States, TIFR, Mumbai and IISc, Bangalore. I chose to join IISc. as a postdoctoral fellow because my research interest was closer to the research focus at the Physics Department at IISc. and also to be with my husband. My husband and I have had Physics as one of the most important links which bind us. Our daughter Roshni who was born in 1996, also shares our enquiring spirit. What has kept me going in Physics against all odds is the support of my husband and my parents in law.

So far I have emphasized the positive influences and not dwelt upon the negative experiences that I have had during my pursuit of Physics as a career. Unfortunately there have been many obstacles in my efforts to establish myself as a research scientist. The discrimination that I have faced has been mainly from the male dominated scientific establishment whose prejudices influence both men and women. I have faced discrimination from other women scientists which has often been as bad as the discrimination I have faced from men scientists. Whenever I have tried to have a rational discussion on this issue, I have come across dismissive reactions. One typical reaction is "Well, men suffer discrimination too". This is hardly a justification. It would be like using Casteism to justify Racism, or the other way round.

I chose to be a scientist. I chose to live and work in India. I chose to have a child and a family. If the Scientific establishment chooses to discriminate against others like me, they are losing about half the brains that this country produces. This is a natural resource India cannot afford to waste.



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Exploring nature's secrets

Satyavati M Sirsat

As one puts pen to paper to write about oneself, events and impressions from childhood onwards well up. After my birth in Karachi and our wanderings through many countries following my father's shipping ventures, my parents – both staunch Theosophists – sent us off to the Besant Memorial School of Drs. George and Rukmini Arundale. Rukmini had brought about a renaissance of ancient Indian art and music at Kalakshetra. During my early teens, I read a fascinating book by Paul de Kruif “The Microbe Hunters”, which left a lasting impression on me. Along with formal education, I also had the advantage of a cultural heritage. I went to Bombay and obtained a degree in microbiology from St. Xavier's College. My first look through an optical microscope at a smear of a mixed gram-positive and negative culture of micro-organisms gave me an emotional thrill I can never forget.

The day after I graduated, I found myself, without much reflection, outside the office of Dr. V.R. Khanolkar, the chief of laboratories, and chief pathologist at the Tata Memorial Hospital for Cancer and Allied Diseases. No phone calls, no appointments – I just stood there waiting to see him. After a two-hour wait, he

called me in and we had a long chat. I did not realize that this was his way of interviewing the young. At last he asked me whether I could manage all that he had talked about. "Of course!" I said with the arrogance of the young. So began my life in science!

Dr. Khanolkar was a Renaissance figure – a man of many parts. A physician with an intuitive scientific bent, a lover of art, a linguist, and a scholar in the literature of many languages. I acquired a broad-based scientific and artistic vision from him.

In 1948, the Ministry of Health, Government of India, decided to make the department of pathology at Tata Memorial into a full-fledged Cancer Research Institute. From a senior doctoral student, I became a founder-member of the new research centre. Three of us were sent abroad to bring back the newly established techniques useful in Biomedical research – genetics, tissue culture and electron microscopy. Along with the methodology of science, I imbibed the scientific culture so vital to modern biomedical research I worked and learnt in the laboratories of stalwarts of science – Hans Selye, Albert Szent-Györgyi, Linus Pauling, Alex Haddow, Charles Oberling, and William Astbury.

I came back to establish the first biomedical laboratory in ultrastructural cytology and diagnostic molecular pathology. Students flocked to the centre, which became globally famous for its work. In my laboratory, we studied the transformation from normal to abnormal cell membranes and cancer, junctional complexes and the secondary spread of cancer, viruses and haematological, breast and nasal cancer. Our main stress was on oral precancer – leukoplakia and oral submucous fibrosis – and frankly oral cancer rampant in our motherland due to the habit of lime-based paan and tobacco chewing. Students who were trained in the laboratory got more than formal scientific training. When Bombay University started undergraduate and postgraduate programs in Life Sciences, it was a real boon!

I was always aware of the teeming suffering humanity in the corridors of the hospital. Besides electron histochemistry, immune electron microscopy, electron autoradiography, cryoelectron microscopy, we were aware of the human aspect of our work. Life science and the terminality of cancer patients led me to start the

Shanti Avedna Ashram (Sadan) – India's first hospice, of which I am the founder trustee-counselor.

I have already explained how romance and reality left an initial impression on my young mind and took me along this path. As to mentors, my first mentor was my father. A scholar by nature, he started life as a professor of English at St. Xavier's College, but shifted to shipping. He was a voracious reader, and a sanskrit scholar. He passed these traits on to his children. He was also an author. My mentors in my scientific life were first, Dr. Khanolkar and, second, who mattered very deeply to me, my husband Dr. M.V. Sirsat. Although there was a large age-difference between us, he was my friend, philosopher and guide. He was an internationally known onco-pathologist. He was deeply versed in the transition from normal to diseased, especially in neoplasia and malignancy. He was a very popular teacher of young aspiring pathologists. Whenever I had a problem with the complexities of this dreadful disease, he solved it with patience and affection. It was a wonderful partnership. He was a deeply supportive guide of my research and was very proud of my professional achievements.

Did I ever feel I would like a change of career? No, never! I could not and even now cannot think of change in profession. It was not a job, it was a life of *Sadhana* and *Tapasya* in the laboratories of Tata Memorial Centre, and indeed the world. It has been a "love-affair" with the work I did and an active emotional life with the knowledge I gained, which I passed on to hundreds of students all over India and South east Asia.

Although retired, I still work as chairperson of the Tata Memorial Centre's medical ethics committee. I worked for 17 years with the Bharatiya Vidya Bhavan Ayurvedic Centre on 'ancient insights and modern discoveries. My knowledge of Sanskrit proved invaluable. I worked on a project on Cancer Nosology of the Vriddhatrayi – Charaka, Sushruta and Vagbhata. It is mind-blowing how fully these ancient scholars' descriptions tallied with modern ones. They had vast knowledge of different tissue tumours and their biological behaviour, benign vs. malignant, bone and haematologic cancers. Their only tools were close observation of the human body, the deceased individual and their intuition.

A few final words to young aspirants: Do you want the honoured label of a scientist? The tenets of life are strict! Be honest to your work and true to yourself. Be disciplined. Never disparage the work of your fellow scientists. Be observant – never distort your log or show records to fit a preconceived theory. Above all, life is to learn – so learn, learn and learn! You are on the greatest adventure – exploration of nature's secrets!



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Researching malaria in the developing world

Sarala K Subbarao

I was born and brought up in Secunderabad in a middle-class family that valued education highly. My parents were formally educated only up to middle school, but they gave all six of their children the best education. In the early 1960's, when girls in our community were not even allowed to get a bachelor's degree, my father encouraged me to join the master's degree course and supported me financially.

My career in science started at the undergraduate level, where I had three majors—botany, chemistry and zoology. Organic chemistry was my favourite subject and zoology my least favorite as it involved animal dissections. Ironically, I had the highest score in zoology and I got into the M.Sc. zoology programme. I graduated in 1964 with a specialization in helminthology. My formal exposure to genetics was in the final year of my undergraduate studies. I was fascinated by Mendel's Laws of Inheritance and their predictability on the phenotypic characters in the progeny and the double helical structure of DNA that is responsible for the systematic inheritance of characters from parents to progeny. It was around the same time that the Nobel Prize in Physiology or

Medicine was awarded to Watson, Crick and Wilkins for unraveling the structure of DNA. All these factors put together made a lasting impression on me and inspired me to study genetics further, though the opportunity to do so did not present itself immediately. After my M.Sc. I taught zoology to undergraduates at Osmania University, Hyderabad.

In 1967, I got married and went to America with my husband. There I got a chance to work with Professor John R. Laughnan, a distinguished corn geneticist. The topic of my doctoral degree dissertation was "The nature and sensitivity of breaksites in the long duplication of X-chromosome following X-irradiation". Cytological analysis of the exceptional offspring from stable line after X-irradiation indicated that the breaksites corresponded to those that occurred in exceptional offspring produced spontaneously in related unstable lines. This finding supported the hypothesis that the breaksites were heterochromatic in nature. The difference in the unstable/stable strains in producing exceptional strains was considered quantitative rather than qualitative, that is, the amount of heterochromatin present at the breaksites. Today this phenomenon may be best explained by involving the role of transposable elements.

Our first daughter was born in 1970. It is after she was born that all my experimental work for the dissertation was done. I obtained my doctoral degree in Genetics in 1973 from the University of Illinois, Urbana-Champaign.

Soon after we returned to India, I got an Insect Geneticist's post in 1974 in a World Health Organization (WHO)-Indian Council of Medical Research (ICMR) funded *Genetic Control of Mosquitoes* project in New Delhi, where I worked on *Culex quinquefasciatus*, a filaria vector, to resolve the variations seen in the cytoplasmic incompatibility/compatibility between Indian and European strains of this species. My research in malaria started in 1975 when the project staff was shifted to the newly-established ICMR institute - Malaria Research Centre (MRC), Delhi. I worked on genetics of phenotypic and biochemical markers for inheritance pattern and linkage analyses, chromosomal aberrations, insecticide resistance patterns etc. in malaria vectors and polymor-

phism in malaria parasite antigens.

My major contribution to malaria entomology has been unraveling the unique biological/taxonomical phenomenon prevalent among anopheline species i.e. identification of morphologically similar but reproductively isolated biological species within morphological taxa. Using genetic and cytological analyses, five sibling species in *Anopheles culicifacies* and three species in *Anopheles fluviatilis* were identified while in *Anopheles stephensi* only ecological variants were found. These three malaria vectors together transmit to about 90 percent of malaria in India. Our extensive field studies have shown that the sibling species have distinct distribution pattern in India. Furthermore, variations were found in resting habits, feeding time and place of feeding, preference to feed on human or animal hosts, susceptibility to malaria parasites, malaria transmission potential and response to insecticides etc. among the sibling species.

These variations suggested that malaria control strategies have to be planned carefully based on the prevalence of sibling species in an area. The identification method used for the sibling species to study the biological variations was species specific diagnostic inversions readable on polytene chromosomes. But there was a need to develop simpler diagnostic assays for field use in malaria control programmes. This need has necessitated the establishment of biochemical- and molecular-genetic laboratories at MRC, and simpler PCR-based diagnostic assays have been developed.

The opportunity to lead research that is relevant to the national health program has been very gratifying. Twenty-five years of research in this area have given me an opportunity to train and guide younger colleagues and research fellows, many of whom have obtained doctoral degrees, and also post-doctoral fellows. In recognition of this research, the World Health Organization (WHO) designated the Malaria Research Center a "WHO Regional Reference Center for the Identification of *Anopheles culicifacies* and Intra-specific Variations". I was also awarded the M.O.T. Ayengar Memorial Award of the Indian Council of Medical Research for Malaria Research.

Though my research has been appreciated and supported by colleagues and superiors, day-to-day difficulties when carrying out research were annoying. It was not easy to accomplish research objectives maintaining research standards. Organizing and planning in the lab, procedural delays in getting reagents, lack of optimal infrastructure, frequent power breakdowns that led to wiping out of mosquito colonies that we reared for years were all a part of day-to-day problems. I had to put in long hours not only in the lab but also at home while taking care of growing children, who had many needs even though they were very cooperative. It was my strong desire to continue research that is of social relevance, cooperation of the supporting staff at the lab and of the family at home that helped me achieve my research objectives. I must also add that never was I discriminated against in my career because I am a woman.

In retrospect, I can now say that I do not regret having declined job offers that I had in the United States in 1973, when I decided to come back to India to pursue research.

From 1975 to 2003, I worked at the Malaria Research Centre, retiring as Director. I am a Fellow of the National Academy of Sciences, Allahabad; Indian National Science Academy, New Delhi, and the Indian Society for Malaria and other Communicable Diseases.



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Science and music: A harmonious jugalbandi!

S Annapurni

I studied in the Government Moyan Model Girls High School, Palakkad where I was born in a conservative and traditional family. My parents, professional musicians, were very keen that I should come up very well in academics as well as music. I am their only child and since I was born after eight years of their marriage, they were quite possessive.

My neighbor, a retired teacher popularly known as “Murthy sir”, took a keen interest in guiding and helping me. Initially I used to be very scared to approach him, to the extent that at times I used to avoid coming out of my house, fearing that he might ask me some questions if he saw me. This fear slowly disappeared once I started talking to him. He used to give me small math problems and challenge me to solve them. Though initially I disliked them, slowly I began to enjoy solving the problems. This was of immense help to me in my early school days, which I realised much later.

I did not take studies very seriously till the ninth standard. Somewhere in the middle of that year, I decided that I had

to secure high marks if I wanted to continue my studies in a good college. I thought that there had to be more to life than getting married and looking after my family. I understood that this should not be the one and only aim in life for a girl. In order to do something more or different, I had to study well. This prompted me to concentrate on my studies: till then, I did not have any particular aim!

I used to sing well and I knew I would do reasonably well in music. I used to like science and maths but did not like languages or literature. One has to use thinking skills to do science and maths. Fortunately Murthy sir used to always encourage me to think by giving me math and science problems. Closer to the exams, I realized that I would have been better prepared for the exams, if I had put in more effort. This was my first realisation that there was no remedy for a lack of preparation! I felt really bad and decided that as far as possible I would never make a similar mistake again.

In the tenth standard, I worked sincerely, but the demands were extremely high. I thought I was doing my best, but my friends were putting in many more hours. I was also participating in music competitions at school and I even represented my school in the state level competitions. When I returned with the second prize, I felt good about it. But Murthy sir, from whom at that time I was taking tuition was angry. He was right, as the mock exams were just round the corner. After that, without wasting any time, I made up a schedule for my preparation for the examinations. I followed the timetable strictly and studied or revised the required portions before the exam. I did not allow myself the luxury of deviating the slightest from the schedule, since I knew I had no choice if I wanted to do really well. When the results came, I was the topper!

There was no looking back: I knew I could do it if I wanted to. I joined the Govt. Victoria College, Palakkad, for higher studies. I would not study every day, but made sure that I read the chapters before they were covered in the class. In preparation for the twelfth standard exam, I again prepared a time table for revision. Unfortunately, I was stricken down with chicken-pox and had to stay at home for two weeks at a crucial time. I could not

concentrate because of high fever. I changed the timetable and revised languages during the time when I was sick. By the time I was better I moved on to revising maths and science. I did well in the exams, to the extent that I got the highest marks in maths and science in the college and second rank overall.

Most of my friends, including the topper, joined engineering courses. Nobody liked physics, and most of my friends who could not get admission to engineering enrolled for maths. Again, I wanted to do something different and I took up physics, instead. I really loved it, because it combined maths and science. Our teacher, Mr. Sudarshan Kumar allowed us to spend extra time in the labs under the pretext of testing the equipment. He taught us the right way of doing experiments with precision, encouraging us to record the actual readings or measurements we observed. If these readings did not lead to the expected values or answers, we had to think of possible reasons for the difference rather than record 'expected' values. This was a very basic and important step to think like a real scientist. These two teachers were responsible for inspiring me and introducing me to the exciting world of science.

I went on to do postgraduation in physics in the same college. All along, I was getting trained in Carnatic classical music, including vocal and violin. When I was doing my postgraduation, I started giving violin performances on stage. I got married though I was not keen to get married, I had to fulfill my parent's wishes. Also, all my friends were married by then. I had to re-schedule my life after marriage, to combine my studies with the responsibilities at home. I joined the Indian Institute of Astrophysics (IIA) for the Ph.D. My husband was all for my continuing my academics, but it was up to me to manage the house and my thesis. There were times when I could not complete my work within the available time. I pulled along, at a slower pace. I realised that it would be easy to abandon something, but one could save it by putting in a little additional effort so I decided to carry on with my studies with that additional effort.

In the middle of my doctoral studies, my husband was transferred to Bombay. We discussed the options and finally we decided that only my husband would relocate to Bombay. I moved

into the hostel at my Institute and continued with my studies and research. My in-laws were living in the same city and expected their daughter-in-law to be present at family functions. When it was time to write my thesis, I concentrated on work alone for six months. My thesis supervisor, Prof. Ram Sagar was very supportive and understood my situation. I am extremely thankful to him. He made it clear that it was my responsibility to make progress though I could set my own pace. After my Ph.D., I had a daughter. I took a break for almost one year after she was born, but continued to keep in touch with the scientific developments from home. Subsequently I joined IIA as a post-doctoral fellow although I had offers of postdoctoral fellowships from a few institutions abroad. I decided to continue at IIA in order to be with my family and at present am on the faculty of the Indian Institute of Astrophysics. I supervise many post-graduate students for their summer projects and guide Ph.D. students in their research. I now have two children who are both in junior school. I continue to play the violin in music concerts although I have to try hard to find time to practise. I also continue to learn — one can never be a perfect musician!

In addition to helping them with their homework I teach my children music. I try to encourage their curiosity with small interesting pieces of information almost every day. I enjoy doing all the three, research, music and training, in addition to looking after my family. I think that women have the right temperament for multitasking and enjoying what they are doing. Maybe I will contribute a very tiny bit to science, but I feel enriched by my opting for science. I think this was the turning point in my life.



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A freedom to question...

Sumati Surya

I must admit that I found it odd when asked to write a piece on my life as a physicist. My contributions to physics are modest and I have lived through fairly unremarkable times and circumstances. What justifies the writing of this essay then, is the 'odder' fact that being a woman physicist makes me unusual.

I was born into a middle-class family which was well travelled and broad-minded. My parents were the primary source for my education until I was about nine years old; my teachers mostly inspired me with fear. My mother and I would sit together in the afternoons and would read, draw, or look over lessons. An early memory is of her using an array of katoris to explain the idea of multiplication. My father travelled considerably, but when in town worked out of an office at home. He gave me puzzles in arithmetic and taught me tricks and ways to rationalise the multiplication tables. This introduction to basic numeracy influenced my enjoyment of mathematics during my school years. Because it was done in a relaxed atmosphere I never viewed it as any different from play. I also had access to an assortment of popular books in science bought for my older brother. I read them with curiosity and only partial comprehension.

By the time I was nine, I had decided that I had no need for a God. I reasoned that there was no room for a heaven in the solar system, and hence no room for God. My mother, herself a believer, handled my queries beautifully by telling me to seek the answer for myself. Years later, I realised that my father was a confirmed skeptic and agnostic. I think this freedom to question played a role in my growing interest in the natural world. When I was in middle school, my mother, by then an active journalist and writer, took special interest in my basic science education. When I was in class six, she along with a young and enthusiastic teacher, translated an excellent book on basic science by Ekalavya from Hindi into English. It brought textbook knowledge into the tangible world and made our science classes very exciting to me. At home, my father, an electrical engineer, would patiently explain how simple household gadgets worked. I didn't always understand, but years later found that stored memory useful.

During high school, my interest in science, and physics in particular, was heavily influenced by my older brother, who had himself chosen physics as his major in college. His discussions with the family about things he had read and studied opened up the entire world of academia to me. Here, it seemed that one could as an adult pursue one's interests single-mindedly, without worries about earning a living! Until class ten, I also had very good teachers who encouraged questioning. I enjoyed listening to and reflecting on their descriptions of the physical universe.

In my last two years of high school negative influences both from school and society began to erode my confidence and motivation. There was a general perception that being female was incompatible with an aptitude for science and mathematics. I also felt a revulsion for the madly competitive atmosphere of an Indian high school. My brother, firmly confident of my interests and abilities, urged me to be more ambitious. This wasn't enough to bolster me and I finally ended up in a local college, majoring in physics. The experience of a mediocre curriculum and faculty was a huge disappointment and I wished I had heeded my brother's advice, if only to have suitable peers to converse with.

My undergraduate education was mostly self-taught and

deepened my interest in physics, though I didn't actively think of it as a career option. The path that followed seemed only natural. This period of self-education was special because I felt no external pressure and hence spent hours mulling and working through basic physics. Although naturally gregarious, I became a bit of a loner, finding my own company and that of my family far more rewarding than what I found readily available at college. The following two years were spent at an I.I.T., a stark contrast to my undergraduate institute. I did not appreciate the pressure, but I did benefit greatly from exposure to both an excellent curriculum and peers. It was here that I met my future husband, also a physicist. He is a feminist and is one of the reasons I continue to do physics today. Despite the travails of living apart for several years during our Ph.D. and postdoctoral years, he has been steadfast in his commitment to support my interests.

I did my Ph.D. at Syracuse University under the guidance of Prof. Rafael Sorkin, who became my mentor in the purest sense of that word. My thesis work was on the effect of topology on the states of quantum gravity. It required familiarity with graduate level mathematics which I had to teach myself. This rekindled my interest in mathematics, and in a sense directed the course of my future research. Subsequently, during my postdoctoral years, I worked on mathematical aspects of general relativity and quantum gravity, and my collaborators included mathematicians. After several rewarding years of postdoctoral research, I joined the Raman Research Institute, Bangalore, where I now work on the causal set approach to quantum gravity.

I don't think I would do anything important very differently! Of course, once having chosen a particular path, one sometimes wonders how the other paths might have been. I do know that I began with the advantage of a supportive family and that I have benefited greatly from deep friendships through demanding times.



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Journey to success

Qudsia Tahseen

In Azamgarh Uttar Pradesh where I was born, girls were not expected to have careers. At most they were supposed to be educated up to BA, to be capable housewives. I was lucky enough to have enlightened parents who considered education of prime importance. Being the oldest child in the family, I enjoyed more attention from my parents than my two younger brothers. My father treated me more like a son and many times I have heard him arguing with my mother to let me study and not to press me to do household work.

I was always among the top students in school. Science was my first love and I was fascinated by the working of the human body. In view of my calibre and interest in science my father sent me to the Government Girls' College. I got a merit scholarship after passing high school: this was my first auspicious step towards a scientific career. In view of my enthusiasm and good performance and the limited opportunities at Azamgarh, my parents decided to send me to Aligarh Muslim University where I could easily get admission on the basis of merit.

I learnt a lot while in hostel and the experience gave me a lot of confidence and the ability to live harmoniously with others.

Since I was away from my parents I tried to focus on my work and not get distracted. I chose zoology as a specialization because of my immense interest in it, thanks to my love for animals! The scholarships I got in BSc and MSc were of relief as I was conscious of spending my father's hard-earned money.

I decided to go in for research and opted for nematology as a specialization at the Master's level. The NET examination was introduced that year and I qualified for a Junior Research Fellowship. I owe a great deal to my guide, Prof. M. Shamim Jairajpuri, who was an ideal teacher, very encouraging and supportive of my research endeavours. He prompted me to strive for excellence. It was he who advised me to start work on the developmental biology of nematodes and I did my doctoral thesis with dedication, finishing it in three years. By this time I was married, and staying in a joint family. My husband proved to be very supportive of my academic endeavours.

My first appointment as a faculty was in 1989 in Women's College, AMU even before I received the PhD degree. The appointment came as a reward in recognition to my academic skills but at the same time posed great challenges. Women's College did not have any infrastructure for research and it was a difficult job to teach at college and then to carry out research work in the Department. However, it was during this period I bagged four young scientist awards including those of Indian Science Congress Association (ISCA) and Indian National Science Academy (INSA), besides publishing a score of papers in journals of international repute. My efforts paid off and I was transferred to the Department of Zoology, AMU, in 1997.

Thereafter, I could devote more time to research and (in this regard) visited Rothamsted, CABI, University of Reading, British National History Museum (England), Scottish Crop Research Institute (Scotland), University of Ghent, Belgium and University of California, Riverside for collaborative research by availing Royal Society-INSA Bilateral Exchange Programme, Rothamsted International Fellowship and DBT Overseas Associateship.

Encouraged by these collaborations, I submitted proposals for funding which then enabled me to procure some

important equipment for research. For a long time after my appointment, I had to decline guiding many students since I did not have a laboratory to provide them work space. I got an independent laboratory only in 2003, about fourteen years after joining service.

The new lab proved lucky for me. I published extensively, and my work on nematode taxonomy got national and international recognition as I remain the first Asian to receive ONTA special award 2005 for sustained excellence in Nematology. In addition to my parents, I owe a lot to my two children who cooperated fully in all my research endeavours. My daughter was only three years old when I first left for England!

Despite my responsibilities towards my family, my science career has not taken a back seat. I love to do science. If I had to do it all over again I would make the same choices, with the hope that the future would have more opportunities and better infrastructure for women in research.



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A journey in the path of science

Thelma B K

I grew up in a different world - a world of innocence, obedience, respect and discipline. It was a world with limited opportunities, with almost no exposure to the outside world; no career counseling, no management or administration courses, no MNCs or BPOs, no mobile phones or the internet. One was lucky to have books at home or at the school library and the opportunity to learn from one's elders, teachers and environment. The family's aspirations motivated children to do well. But, I know that if I had to choose a career in today's time and world, I would still become an independent, free-living and free-thinking scientist. How and why I became a scientist is not difficult for me to relate and I am so honored to share my path - my background, the options I had, my sources of inspiration and motivation - in this compilation, 'Lilavati's Daughters'.

I came from a pretty little town called Madikeri, situated in the hills and valleys of a heavenly place called Coorg, south of Mysore. I was raised by a very loving, caring and progressive family - which included my parents, grandparents and several aunts - in a small house with a large backyard. My parents were busy government officials. My grandfather was a highly disciplined, gentle

yet firm man who had served in the British army and was an art teacher in a government school. One of my aunts, who was the first woman to serve in the government office in Coorg, took on the role of our mother and teacher. In our household, there was no discrimination done between boys and girls. Everyone was held to the highest standard. I began primary school at the age of 3. We got the best education middle-class parents could afford because, our parents repeatedly reminded us, education was the one thing which would stand by us.

I had no pressure from any teacher to pursue a specific field. I loved chemistry and biology but had no chance to read about scientists. Performing well in our studies was the only focus. The crucial moment came when I was in class nine and had to choose which stream to take: arts or science. Because science needed greater understanding and logical approach, science was believed to be only for the brainy, arts for the dull ones. These stereotypes worked their way into our mind as children.

The evening before I had to make my choice, I told my aunt that I wanted to take science. Still reeling from my performance on my tests, she shortly responded, “you should take arts because studies in science need dedication. you are only interested in playing, not studying.” The next morning, as soon as the school bell rang students formed two queues one for arts and the other for science. Sadly, I joined the queue for taking admission in the arts stream. My craft and needlework teacher saw me and pulled me out of the line. “What’s wrong with you? Why are you in this line? Go, join the science line”, she ordered and I obeyed. I walked back home, afraid to face my aunt. I told her what happened and what my teacher said.

In Class X, I was the only one in my school to get first class in all four parts. The next big decision was which subject I would take in college. My father wanted me either to do Masters in maths or join the IAS, but my heart was elsewhere. It was my dream to become a doctor. To this day, the sight of a doctor treating his patients fascinates me.

My family was supportive. I moved away from home and started college in Bangalore. In spite of my lack of dedication, I

managed to pass my exams with first class. Unfortunately, I was still under age when the time came to fill out forms for medical school. Everybody agreed that there was no point wasting three years to go back to medical school. Upon completing my B. Sc., I decided to pursue a masters in zoology.

While doing my masters, the head of the department gave me cytology as the special paper, instead of physiology – which I wanted. I could not come to terms with their decision and resisted dedicating too much to the course. I constantly interacted with a mentor and her students who were pursuing Ph.D in animal physiology. The energy and discussions in her lab helped me make the final decision to opt for a career in science. I decided to pursue a Ph.D in biomedical research.

Due to poor preparation, I did not get to do my Ph.D at any of my first choice schools. I began my Ph.D. at Delhi University. I moved even further from home. I was a single girl getting onto a train headed to a place where people spoke the language I did not know.

My obsession to do biomedical research led me to my Ph.D. mentor Prof. S.R.V. Rao. The lab had a very relaxed environment and the passion and commitment to a research question that I saw in my teacher made a lasting impression. Prof. Rao spent long hours at work, discussing not just the project at hand, but all other contemporary findings. He nurtured a passion for scientific research and emphasized the research process, rather than the results. I enjoyed every moment in the laboratory and tried to learn as much as possible.

I joined the Human Genetics Laboratory at the Children's Hospital in Basel, Switzerland for my postdoctoral fellowship. Because I was in a hospital setting, the experience was very satisfying. I returned to India eventually. I decided to become a teacher - scientist so that I could inspire others the way Prof. Rao did. I joined the Genetics Department at Delhi University, where I continue to work and serve even today.

The journey has been long but not arduous, because science is my passion and I enjoy and cherish every moment of it. My commitment is deep and unswerving, and even today, I

continue to discover my potential. I will always cherish the trust and faith my family put in me, as it was central to developing confidence early in my life.

So my path, perhaps not unique, was a special blend of luck, determination, opportunities and guidance.

As said by Guru Sri Sri Ravi Shankar, for our prayer to be answered, the desire has to be intense and the greater the intensity of the desire, the greater will be the gratitude; but for the desire to become intense, time and need are required which ultimately leads you to devotion. I have experienced this and while I am devoted to scientific pursuit, I remain ever grateful to my family, Gurus and Gods, who shaped my path of life in unseen ways.



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Joining the family business

Vidita Vaidya

I grew up on a diet of literature and science, given that my grandfather and granduncle were Gujarati novelists and poets of repute, and my parents, committed medical doctors and scientists. These two career paths were almost a natural progression in the family business, and given the struggle it took for me to write this piece I believe I chose between the two wisely! When my parents talk of my childhood, the usual refrain is not about whether I did well academically, or whether I was an adorable child, but that as a four-year old observing a caterpillar dangling by its own spool of silken thread I asked “how does it know how long the thread has to be for it to make a perfect little home?”. I am sure many children have said similar things but that my parents wear this initial proof of my “scientific temper” with pride is perhaps a reflection of the milieu in my home growing up. Given this, it was very unlikely that I would end up an investment banker.

My earliest childhood memories are of long walks with my parents on the verdant CIBA-Geigy Research centre campus in Goregaon, Mumbai where I grew up. These walks were a mini-discovery process for me, and through encounters with all forms of insects, birds, flowers and the occasional fox and snake began my interest in Biology. My father, Dr Ashok Vaidya, is a clinical

pharmacologist and my mother, Dr. Rama Vaidya, is a reproductive endocrinologist. My parents, today in their 70's, still continue to work ceaselessly with a passion and motivation for science. It was through them that I first learnt biology. In the 70's and 80's, the Ciba-Geigy research campus in Mumbai had a critical mass of bright and dedicated clinical and basic researchers. The beautiful environs of the campus – lush greenery, old-world bungalows and above all witnessing often the enthusiastic scientific debates– left an indelible impression on my mind

During my early years another key influence was my uncle, Dr Akhil Vaidya who is a molecular biologist, in the US. He used to visit us frequently and would always bring with him many books. One such book that he gifted to me when I was thirteen was “The Brain” by Richard Restak. That's when the penny dropped that in the recesses of the brain lay the answers to my caterpillar question, of how ants and bees communicated with one another and how my cat had formed such tight association to an earlier house many years after we had moved. It was during this period of time that my interest in Neuroscience began to crystallize.

At the end of my schooling, I was faced with my first significant decision. I had the opportunity to join medical school or join St Xavier's College in Mumbai, for a Life Sciences degree. It was the latter that I felt allowed me to ask and pursue questions in biology for the sheer fun of it. The Life-sciences program at St. Xavier's is unique and faculty encourage their students to problem solve, experiment and enjoy the process of a broad-based education in basic life-sciences. A summer spent working with my uncle in his lab at Drexel University in Philadelphia introduced me to bench science and the rigors of lab work and I was hooked.

After my undergraduate degree, I left India in 1992 to start my thesis work in the Neuroscience program at Yale in the US. My thesis advisor Professor Ronald Duman, besides being a terrific teacher and thesis guide, also mentored my growth as an independent scientist. It was these years that were seminal in further shaping my interests in Neuroscience and in particular in the neurobiology of mood. Graduate school in the US requires you to go through a rite of passage- the qualifying exam, which if you

emerge unscathed, allows you to begin your Ph.D. work. Amongst my qualifying exam committee was Professor Amy Arnsten. She has had a lasting impact on my view of how to successfully juggle the multiple hats a woman scientist wears – scientist, mentor, friend, mother, wife etc. While I had already witnessed the struggle many women at Yale went through to balance these multiple demands, it was important for me to see that it was doable if one set ones own parameters rather than jumping through the hoops set by the world. Amy sent me a card congratulating me after I finished my qualifying exam. More often than not the bells and whistles or flowery touches are frowned upon in the world of science, but that Amy marched to her own band was clear to me from that fact that she did not hesitate to tell me in her own unique way to celebrate. While it was a small gesture of Amy's, it left a big impact, there is no cookie cutter model of the traits one has to have to be a scientist other than the ability to truly enjoy doing science.

It was also during my years in graduate school that I met my husband, Ajit. Unlike the other key people in my life, Ajit was not in any shape or form involved in science – in fact he is in the corporate world. His interest in my research and sometimes startling insights into a research problem I am grappling with has been an important lesson to me that a scientific temper is not the solitary purview of scientists. Ajit & I have had to pay our dues by spending many years apart to follow our own career aspirations. After a couple of years (together for a change) in the UK where I did a post doc at Oxford we returned to India in March 2000. I was returning to India, 8 years after I had left to join the Tata Institute of Fundamental Research in Mumbai, as an independent researcher.

The past seven to eight years at TIFR have had all the hues that every scientist in India has to go through. Rewarding, frustrating and humbling at the same time. The process of setting up my lab, building the animal house, writing grants and guiding students have been quite rewarding. I have enjoyed the scientific freedom that I have been given at TIFR. I am still at the early stages of my career and have much to look forward to. I know that being in India, at TIFR, will provide me the platform and support

structure to continue doing the only thing I've ever wanted to do in my life. Along the way I have also contributed to the family business by adding on the latest member – Alina Vaidya Mahadevan. Through her eyes I find myself rediscovering the wonders of biology. Motherhood has also served to reemphasize how important family, in this particular case my in laws, are in supporting the constant juggling act of full time science and motherhood.



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Being a scientist and a mother

Shikha Varma

I remember my father teaching me science when I was a young student. He was an engineer and always stressed the importance of education. He was an early influence on my interest in science. Even though he retired by the time I finished class eleven, my education, and that of my elder brother, remained major priorities for my parents. Although my parents had mostly traditional values, I was always encouraged to study, do well, and, most importantly, become independent.

I went to I.I.T., Kanpur, in 1982 to do my MSc. The teachers and overall atmosphere, although grilling, were highly motivating. Here, I met many teachers who were very supportive. Prof. G K Mehta's Course on "experimental methods" was really inspiring and sometime after that I became sure that I wanted to do research in experimental field. At I.I.T. I met Ajit Mohan, senior physics student, whom I married after finishing M.Sc. in 1984, and later we both did Ph.D. from Syracuse University in the U.S.

For my Ph.D., I studied the electronic structure and the band structure of thin mercury films on silver substrate, using Ultra-violet Photoemission Spectroscopy and Synchrotron Radiation. I finished my Ph.D. in 1990 and for postdoctoral work went to Case Western University in Cleveland, and then to the University of Wisconsin at Milwaukee, where I studied the core level photoemission spectroscopy of oxides using X-ray photoelectron dif-

fraction. In 1993, I went to the university of California-Santa Barbara where I studied the MBE and MOCVD grown quantum dots structures by AFM and STM.

My husband Ajit and I had a long distance marriage for four years as we were postdoctoral scholars at different universities in the U.S. Now we felt was the right time to apply for permanent positions in India and we both got offers for faculty positions from the Institute of Physics (IOP), Bhubaneswar. In the summer of 1994 we had a son, and three months later joined IOP.

Fortunately, both Ajit and I got jobs at the same institute. Knowing the problems of several physicist couples, who work at different places, I strongly feel that the unwritten convention at many places of not offering positions to husband and wife together, even when both are suitably qualified, is sapping a lot of energy and motivation from young scientist couples. These decisions are often guided not by stated rules but by the instincts and misconceptions of colleagues who in most cases happen to be male.

My early years at IOP were very difficult, tedious and demanding. In the absence of any experimental system that I had used up to that time, I learnt and started working with the existing accelerator facility and the available techniques of Rutherford Backscpectrometry and Channeling. With a small child, new experimental set-ups and the pressure to establish myself at a new institution could have become insurmountable without the support of an understanding husband. We tried to balance the sharing of time depending on our professional requirements, which for me being an experimentalist were sometimes more stringent. I could completely depend on him at all times. Without this kind of strong support it would be very difficult for any woman (since the support system exists for men by default anyway), with small children, to continue without taking a break in her career. Sadly, in the present scenario of diminishing job opportunities, authorities, who mostly happen to be men, tend to consider a break of a few years as showing a lack of professional commitment, especially when they are considering a woman for a permanent position.

As I was an experimentalist, my experiments would often

run through the night. Due to the lack of characterization facilities at IOP in those days, I also visited several other laboratories in the country to conduct experiments. The first time I went for a conference leaving my son at home, he was six months old. Trust-worthy domestic help for providing some support with childcare was not always available. For the first few months at IOP, in the absence of any crèche facility, flexible time scheduling at work became essential for us. Fortunately, the director at the time, Prof. V.S.Ramamurthy, was very understanding and encouraging. At that time it fully dawned on me how difficult it is to take care of a child, while both parents pursue their careers.

After a few years, when the funds became available, I developed a surface science laboratory at IOP with facilities for X-ray Photoelectron Spectroscopy and Atomic Force Microscopy. At present, I have three graduate students working with me. I find both roles – of a scientist and a mother – truly fulfilling and rewarding. I feel lucky to be able to pursue the career I desired. At the same time I was also able to experience the deep emotions of motherhood and the pleasures of raising a child.

A policy decision should be made to encourage the hiring of deserving couples to permanent positions at the same place so that early years of research career do not get wasted on long distance commuting or the woman sacrificing her career (which happens most often) or severely compromising her career as well as independence by taking pool officership or a long-term postdoctoral position near her husband's place of work. Senior women scientists should be involved in taking policy decisions relating to hiring norms and should also counsel young women, at all stages, on their career prospects. Over the years, I have seen several women whose drive to become scientists did not get fulfilled, primarily due to early family responsibility, lack of childcare facilities and absence of strong support systems at home. Support of family is essential to sustain the motivation, curiosity, imagination and desire in women. But it is also essential for women with small children to have access to good childcare facilities, provided by the organizations where they work, some flexibility in time schedule and the support and understanding of the authorities.



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My journey into understanding how cells and organisms are made

Usha Vijayraghavan

With biotechnology so much in the news these days it may be difficult to appreciate that for a late 70's high school student a career in biology was something not obvious. I was born into a family with a surfeit of engineers and grew up in an environment that greatly valued education. Even so no women in my immediate family had yet taken a career path so it was not obvious that I would turn out to be where I am. My aptitude for science was evident from high school. I had excellent teachers who recognized my eagerness to go beyond the curriculum and above what mattered for excellent board results. I was encouraged to give lectures to my class on the chemistry of photosynthesis and respiration. This was perhaps one of my earliest exhilarating moments that revealed the beauty and diversity of biology operating within the precise laws of physical sciences. My decision to take up biology, and not engineering or medicine, was initially incomprehensible to my immediate circle of family and friends! No one knew where studying biology would lead me, but perhaps my parents humored me thinking that I did not intend to

take up any specific profession any way.

I obtained a Bachelors degree from Delhi University where the faculty of Sri Venkateshwara College recognized from very early on my aptitude and commitment. I sat my first year University exams while suffering chicken pox in an "isolation room" created in the college. Such was their confidence in my potential! I went on to top the University bringing to my college one of its many "Firsts" in its early years as a South Campus college of Delhi University. My strengths were a near insatiable appetite for reading and quick comprehension. Subsequently, I did a master's degree in the then "interdisciplinary subject": Biochemistry, which was not offered at Delhi University or Jawaharlal Nehru University. The decision to leave home was easy for me but my grandmothers couldn't believe that nothing in the vast curriculum of Delhi's universities interested me! At Post Graduate Institute for Medical Education and Research, Chandigarh my interest in research was reaffirmed. I then narrowed down a couple leading Indian Institutions and some in USA to apply to for my further studies. Around that time I met Vijayraghavan who was pursuing his Ph. D. in biology at TIFR, Bombay, after his training at IIT Kanpur as a chemical engineer. From the outset he and his family actively encouraged my academic pursuits.

Once we were married and Vijay had decided to go to Caltech for his post-doctoral work it was clear that I should work towards securing admission in one of California's highly ranked universities. This was no easy task but with rigorous preparation and perseverance I was admitted to Caltech for my graduate research with Prof. John Ableson. His was among the few leading labs working intensively on the mechanism of mRNA splicing. This is a process that we now know contributes greatly to how eukaryotic cells generate a large repertoire of functional molecules from defined inherited genetic material. The information in the inherited genome is first transcribed to a transient molecule called pre-mRNA from which functional segments are generated by "splicing". Understanding the details of this process is important as derangements cause diseases and affect normal development. Exploring this process in a simple laboratory model would provide

clues on how genes may be regulated in other more complex organisms. I took a genetic approach using the bakers yeast where my hard work paid off. In this process I also learnt to hold my own in a highly competitive research field. The joy in making discoveries is compounded by an invigorating environment. At Caltech one learnt a lot in the formal seminars and as much by just being around the stalwarts in biology. The corridors, cafeterias and faculty club were always abuzz with excitement! I mingled with others working on cutting edge topics in bacterial genetics, neurobiology, immunology, developmental biology etc.! An important part of my training was learning to adopting a genetic approach to unravel a biological pathway; the art and science of which has stood me in good stead. Towards the end of my graduate work came decision making time as Vijay was returning to TIFR, Bombay. I had to identify my long-term objectives. I decided on plant biology as an area for my post-doctoral research and began my tryst with plants in the laboratory of Prof. Elliot Meyerowitz at Caltech. His team was breaking new exciting ground on the genetics of flowering using a remarkable weed- *Arabidopsis*. As many aspects of flower formation are evolutionarily conserved so the knowledge gained had a direct bearing on food crops. My teachers and my peers thus molded me before I returned to India as a Lecturer at the Indian Institute of Science.

At IISc, I began to research the regulation of gene expression using microbial and plant model systems. Our tools were largely genetic ranging from classical genetics to modern functional genomics. Our recent work on rice genes, which are related to genes in the model weed, illustrate how evolution can create diverse plant forms by networking conserved factors in different ways. Our work on RNA splicing is throwing new light on the complexity of gene expression. Building a research team with young aspiring scientists is the best part of being a researcher and a teacher. Of course, there are exasperating moments when much time is spent and little progress is made. Developing a patient yet rigorous approach is what pays off. One needs much fortitude in the real world of competitive grants and administrators. But none of these difficulties are unique to a science career. Such challenges

are commonplace if one aspires to be the best in the chosen area. In today's communication enabled world flexibility of work time is an enviable advantage that a scientist can use judiciously to juggle work and family life. I am privileged to get unconditional support from Vijay, and our immediate family, while I continue my career and we bring up our son. In general, Institutional support for women with families leaves much to be desired in most Indian establishments. But this is not an issue limited to career scientists. These issues plague most Indian establishments and require a combination of Institutional commitment to women's issues and a changed perception in society that values women at the work place. On the balance, the inner drive to excel in ones chosen profession counters any of the downsides of being a career scientist. There are great opportunities, many professionally and personally gratifying moments waiting to be discovered by a woman who takes to science as a career!



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The making of a woman scientist: A personal experience

Saraswathi Vishveshwara

I am a Professor in the Department of Molecular Biophysics, Indian Institute of Science, Bangalore working in the area of computational biology. The focus of my research is to elucidate the structure-function relationships in biological systems. The work involves the use of computational- mathematical techniques to understand the functioning of macromolecules such as proteins. The challenges in this field are two-fold: one is to gain insights into biological systems through established methods and the other is to develop methods to probe biological systems. This is truly an interdisciplinary area, which requires the knowledge of biological systems, the chemistry of molecules, and the principles of physics and mathematics. I have thoroughly enjoyed working in this area, which provided me a glimpse of how marvelously the biological systems work. In this article, I focus on the factors which led me to choose this area of research and what factors played a role in shaping up my career as a professor in this field.

The making of a scientist can happen in many ways. Success

in this process is the culmination of several factors, such as upbringing, motivation, and environment. There is also society at large, whose attitude plays a predominant role in the case of a woman scientist.

I was born and brought up in a small town in Karnataka. Ours was a typical middle-class joint family with a large number of siblings. This was soon after India won its independence. There was an all-pervading sense of nationalism; my mother was proud of the fact that her brothers had participated in the national movement, although in a mild form. As my grandfather was a teacher, there was great respect for education in the family. My father's main aim in life was to give children as much education as possible, irrespective of whether the child was a boy or a girl. As a result, we girls enjoyed all the privileges our brothers had, along with the warm affection showered especially on girls, as is common in a traditional family. Thus, we had the best of both worlds: the healthy values of a traditional family as well as the liberal encouragement to acquire knowledge and education without gender bias.

All this could well apply to any serious scientist, irrespective of gender. On the other hand, certain specific questions arise in the case of a woman scientist. For instance, was the path to a scientific career a smooth one without hurdles? Or were there challenges that had to be faced as a woman, particularly as an Indian woman? My own experience is that women do not need any undue special push to achieve what they want. However, specific deterrent factors, such as gender bias, should not come in the way either. Furthermore, it would help if simple privileges such as flexible hours and extension of age limit in starting one's career are made available to compensate for the time spent in raising a family. Once these basic needs are fulfilled, a woman can perform in science as well as a man, as is true in any sphere of activity. All said and done, the most important factor in science is one's attitude towards the pursuit of knowledge and creative activity, which has to be inculcated and nurtured from a young age.

I obtained both my B.Sc. and M.Sc. degrees from Bangalore University. Although my specialization in M.Sc. was in biochemistry, I was exposed to other branches of basic science to a

reasonable extent. Consequently, I had no problem in shifting to quantum chemistry for my Ph.D., which I did at the City University of New York, under the guidance of David Beveridge. Later, I worked as a postdoctoral fellow with well-known quantum chemist John Pople, Nobel Laureate, at the Carnegie Mellon University, Pittsburgh. I returned to India and started working as a postdoctoral fellow at the Molecular Biophysics Unit where I eventually became a faculty member.

Currently, I am fortunate enough to have a good scientific environment and the freedom to shape and pursue my own line of research. The most rewarding experience is to interact with youngsters, who spend several years in the laboratory, working towards their doctoral degrees. It is highly gratifying to motivate bright young students and guide them in their research. The most important aspect of this scientific endeavour is the continuous learning process. Quite often, students become part of our lives by keeping in touch with us even after leaving the institute and sharing with us not only their academic achievements but also their personal lives.

I was fortunate enough to have had full support from my husband and his family to pursue my career as a scientist. It does require understanding and adjustments from all people concerned. Ultimately, this can be a happy and rewarding experience.

On the job market, despite all talk of equality, women are definitely at a disadvantage for various reasons. One is the attitude, in general, of doubt harboured by decision makers regarding women's efficacy of performance in view of their family responsibilities. Under these circumstances, patience and perseverance help. Of course, opportunity must knock on the door as well. My case was no exception in this regard. I too had to go through these difficult phases before reaching the stable equilibrium that I now enjoy. Nevertheless, it is always a pleasure to have children around and participate in their development and activities. It is up to us to teach them to adjust to our working habits and schedules as working mothers. A happy and vibrant family environment can result from such a mother-child interaction. In my own case, this has indeed happened, leading to our two daughters pursuing sci-

entific careers by their own choice. Having a husband who is himself a scientist has helped a great deal in this regard.

Was process of becoming a scientist a nurtured dream? No doubt, it is always good to have long-term dreams, but it is also necessary to have more focussed short-term goals in sight. At each step, we have to concentrate on the immediate aim and strive to achieve it. Many such steps taken would add up to a path that will hopefully lead to the ultimate destination, which may not even be known beforehand and may not correspond to your original dream. The most creative and exhilarating experience is to follow a course that has not been traversed earlier, a course that is perhaps a meandering one with surprises at many turns. I can only describe this journey by quoting the Spanish poet Antonio Machado:

*Traveller, there is no path.
Paths are made by walking*

By and large, it is not difficult to achieve what one wants, if the aims are within the limits of one's own environment. If the goals are beyond these limits, one has to be much more adventurous and be ready to take chances. Of course, there is also the radical alternative to change the society itself. I have chosen the first path, where I devote maximum effort to my profession, yet remain in harmony with the environment. A large number of women scientists can achieve this. In fact, the present generation of young women have more opportunities and better social acceptance. Pursuing cherished dreams can be a richly rewarding experience for those young women in science who make use of these opportunities.



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Answers lead to more questions

Shashi Wadhwa

I was born in a Punjabi family after the Indo-Pak Partition in 1948. My parents raised six children at a time when the country was going through a resurgent constructive phase and were very conscious of the need to provide the best education for us all. While my mother took care of our material, physical and emotional needs, it was our father who was the driving force in the educational process. I still remember the maths sessions with him which left us all in tears. The passion with which the science teacher at St Joseph's Convent and the Reader of Zoology at Home Science College in Jabalpur taught us has left an indelible impression on my mind. Being a bright all-round student, with gold medals in science subjects at high school and intermediate college at the state level, at my father's behest I entered the portals of the Medical College at Jabalpur.

Soon after finishing medical school in 1970 and a residency in gynecology and obstetrics, I got married and came to Delhi at the All India Institute of Medical Sciences where my husband was doing his registrarship in urology. Here, I completed the remaining six months of residency in pediatrics, guided by the

thought that it was best for women to practice these branches of medicine. At the end of the residency, I joined the Anatomy Department at AIIMS to teach undergraduates.

I joined the postgraduate M.D. course, earlier referred to as MS. in anatomy in 1972 and here, while pursuing my research thesis on cerebellum and cerebellar nuclei in *Macaca mulatta* under Professor N.H. Keswani, I engaged myself in the study of the nervous system. This had fascinated me as a medical student, but the transition from medical training to the scientific technology arena was not easy. I obtained my M.D. degree in 1974, and my interest and willingness to learn pushed me into acquiring further technological skills during my senior residency of five years in the department. Dr Gomathy Gopinath helped me in my endeavours and forays.

I joined the faculty at AIIMS as a Lecturer in 1979. My interest gravitated to studying how different areas of the human nervous system develop, the departmental head, Professor Veena Bijlani encouraged me to register for a Ph.D. but with two children to handle I was reluctant but finally, after a lot of persistence, I registered for a Ph.D. course in 1985.

I submitted my Ph.D. thesis in 1987 under the guidance of Professor S Veena Bijlani and P.N. Tandon. Thanks to INSA Hungarian and IBRO-UNESCO fellowships I got an opportunity to visit the Semmelweis University at Budapest and to work with Professors Jozsef Hamori and Tamas Freund. Here I learnt immunohistochemistry, combination of Golgi and immunocytochemical techniques, and computerized quantitative methods. On my return, the human fetal retina became the focus of my interest.

These studies were carried out at a time when molecular biology, genetics and non-invasive technologies to understand brain functioning and development were at their peak and our efforts seemed meagre and unfashionable. Fortunately, there is now a resurgence in knowing more details about human brain development based on emerging evidence that neurologic diseases like schizophrenia, autism, epilepsy begin early in life and have a developmental basis. Our studies provide valuable information on

the status of detailed development of at least some of the human brain regions.

Throughout my career, I have focussed on research, teaching of anatomy and my family. I feel privileged to have had the opportunity to learn about the developing brain and marvel at the way nature created the brain. Science has helped me understand the brain and humanity. Science has helped me give back to society. For those in science, I believe science is addictive and in neuroscience research the excitement continues longer because the moment you find answers even more questions arise.

Contributor Profiles



E K Janaki Ammal (1897–1984)

D.Sc. (1931, Michigan), Founder Fellow of the Indian Academy of Sciences. Winner of Padmashri award. Was a renowned botanist and plant cytologist who made significant contributions to genetics, evolution, phytogeography and ethnobotany.



B Vijayalakshmi (1952–1985)

Ph.D. (1982, Madras). For her research she studied relativistic wave equations and their properties. She expired on 12th May 1985 at the age of 33 due to cancer. She had 11 papers to her credit in international journals.



A Chatterjee (1917–2006)

First woman D.Sc. (1944, Calcutta), FASc, FNA, Khaira Professor of Chemistry, Calcutta University. Recipient of the Padma Bhushan. The numerous awards she won include S S Bhatnagar award, C V Raman award of the UGC, P C Ray award, Sisir K Mitra Lectureship and Dr G P Chatterjee Lectureship. First lady president of the Indian Science Congress, member of Rajya Sabha. Her area of interest was natural products with special reference to the medicinal chemistry.



Anandibai Joshi (1865–1887)

Medicine (1886, Philadelphia), Anandibai Joshi, the first Hindu woman to obtain a medical degree in the Western hemisphere, was born Yamuna Joshi on March 31, 1865 in Poona, India. She was the first lady to complete medical education in the USA. She died in Poona at any early age of 22.



Iravati Karve (1905–1970)

Ph.D.(1930, Berlin). This renowned anthropologist was Head of the Department of Sociology and Anthropology at Deccan College. She presided over the Anthropology division of the National Science Congress in 1947. She wrote extensively on a wide variety of academic subjects and otherwise. Her writings include the highly acclaimed book 'Yuganta' which won the Sahitya Academy Award.



Anna Mani (1918–2001)

FASc, FNA, Ph.D (submitted 1945, Madras). The only woman scientist to work with C.V. Raman, is well known for her work in atmospheric physics and instrumentation. She contributed to the study of radiation, ozone and atmospheric electricity, both on the surface and in the upper air using special sounding techniques. Joining the India Meteorological Department in 1948 she rose to become the Deputy Director General of Observatories in Delhi.



Kamal Ranadive (1917–2001)

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Abbreviations Used

AIIMS	All India Institute of Medical Sciences
BHU	Banaras Hindu University
CLRI	Central Leather Research Institute
CSIR	Council of Scientific and Industrial Research
DST	Department of Science & Technology
FASc	Fellow of the Indian Academy of Sciences
FNA	Fellow of the Indian National Science Academy
FNASc	Fellow of the National Academy of Sciences
FNAE	Fellow of the Indian National Academy of Engineering
IASc	Indian Academy of Sciences
IAU	International Astronomical Union
ICAR	Indian Council of Agricultural Research
ICMR	Indian Council of Medical Research
ICTP	The Abdus Salam International Centre for Theoretical Physics
IISc	Indian Institute of Science
IIT	Indian Institute of Technology
INSA	Indian National Science Academy
ISI	Indian Statistical Institute
JAA	Journal of Astrophysics and Astronomy
NAMS	National Academy of Medical Sciences (India)
NASI	The National Academy of Sciences
NCBS	National Centre for Biological Sciences
NRI	Nutrition Research Institute
NSCA	National Science Congress Associations
SMIEEE	Senior Member of the Institution of Electrical and Electronic Engineers
TIFR	Tata Institute of Fundamental Research
TWAS	Third World Academy of Sciences
WiS	Women in Science

